PSYCHOSURGICAL
PROBLEMS

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By

THE COLUMBIA GREYSTONE ASSOCIATES
SECOND GROUP

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EDITOR'S PREFACE

"Psychosurgical Problems" represents the second report of "combined operations" of the research team known as the Columbia Greystone Associates—a group made up predominantly of medical scientists and clinicians from Columbia University's College of Physicians and Surgeons and the New Jersey State Hospital at Greystone Park. The first report, "Selective Partial Ablation of the Frontal Cortex" (Hoeber, 1949), of this group dealt with an investigation of the biologic, psychologic, and psychiatric aspects of psychosurgery (particularly topectomy) as applied to psychiatric subjects, and terminated with the finding that while it was possible to return a substantial number of institutionalized psychiatric cases to their "home" environments, no obvious explanation for such return could be found in the studies conducted.

In the present study* several other less commonly employed psychosurgical procedures (notably cortical venous ligation and thermocoagulation) were utilized in an effort to throw into relief any biologic, psychologic, and psychiatric alterations which might be produced. New test procedures were also employed and the biologic aspects of transorbital lobotomy were explored. In addition, this study has moved into an examination of the influence of social environmental factors upon the postoperative course of psychosurgical patients.

An appendix is included giving the status of the patients included in the first project, two years after their operation. Additional, still later, material on these cases is included in the first chapter, which brings our information up-to-date at the time of going to press.

*This study was supported in part by a grant (M. H. 118) from the United States Public Health Service.

CONTENTS

Chapter 1

NATURE OF THE PROJECT

Fred A. Mettler and Marcus A. Curry
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The development of methods designed to deal with problems involving more than 3 or 4 variables and less than an infinite number is new. The first Columbia-Greystone project was an attack upon a research situation involving such an intermediate number of variables and the technique employed in its prosecution was that of simultaneous observation by means of collaborative study. While the work was in progress, an interesting article by Warren Weaver ('48) appeared. This classifies scientific problems into: (1) problems of simplicity, in which the number of variables rarely exceeds 4 and is preferably kept to 2; (2) problems of disorganized complexity, in which the number of variables approaches infinity; and (3) problems of organized complexity, in which "a sizable number of factors are interrelated into an organic whole." Weaver goes on to point out that as early as the seventeenth century, science had learned to deal with problems of simplicity, largely by utilizing mensuration in the physical sciences, and, in the twentieth century, invaded the field of disorganized complexity by applying new statistical and mathematical techniques to physical problems. Of problems of organized complexity he said ('48, see p. 540), "These problems—and a wide range of similar problems in the biological, medical, psychological, economic, and political sciences—are just too complicated to yield to the old nineteenth-century techniques which were so dramatically successful on two-, three-, or four-variable problems of simplicity. These new problems, moreover, cannot be handled with the statistical techniques so effective in describing average behavior in problems of disorganized complexity.

"These new problems, and the future of the world depends on many of them, require science to make a third great advance, an advance that must be even greater than the nineteenth-century conquest of problems of simplicity or the twentieth-century victory over problems of disorganized complexity. Science must, over the next 50 years, learn to deal with these problems of organized complexity."

On the preceding page Weaver pointed out that problems of organized complexity involve "dealing simultaneously with a sizable number of factors which are interrelated into an organic whole." So it

seemed to us also. As we previously pointed out (Columbia Greystone Associates, '49) the precursor of our method of approach to a complex medical problem was the technique of cooperative research so profitably employed during the Second World War. It is interesting that Weaver has also selected this, which he calls "the 'mixed-team' approach of operations analysis" as one of the 2 modern techniques of dealing with problems of organized complexity. (The other technique he selects is essentially the use of remote derivative machines —which attempt to use on the kind of problems with which we have been concerned have thus far been relatively unprofitable, in our laboratories at least.) Weaver speculated about the effect of such techniques upon individual research (a subject with which we dealt in our first monograph) and might well have questioned whether, under circumstances less compelling than a war, scientists would choose to work together—a question which was raised by Waldemar Kaempffert in reviewing Andrus et al. ('48). That the mixed-team approach of operations analysis is possible in peace as well as war was demonstrated by the first Columbia-Greystone project (Columbia Greystone Associates, '49). That the method does not disorganize the area in which it was employed and that it can profitably be repeated in the same area is proved by the present communication which constitutes the group report of the second Columbia-Greystone project.

NATURE OF PRESENT PROBLEMS

GENERAL RESULTS OF THE FIRST PROJECT. As a result of the first Columbia-Greystone project (Columbia Greystone Associates, '49), several observations were made.

1. In the first place it was found that it was quite unnecessary to disconnect the major portion of the frontal lobes in the supposedly "incurable" psychotic patients studied in the first project in order to secure as high a percentage of returns to society as can be obtained with lateral transcranial ("prefrontal") lobotomy. Reference to figures 1 and 2, which have been brought up to February 15, 1950, shows the pre- and postoperative record of institutionalization of the 48 individuals who comprised that study. At the present date, November 10, 1950, 3 1/2 years later, of the 48 individuals (24 operated and 24 controls) studied, 4 (cases 12, 15, 34, 39) have been returned to society and are still out of the institution without having passed through any surgical procedure. Of 23 operated cases surviving 6 months after operation, it was possible to release 16 (cases 2, 3, 4, 7, 13, 19, 21, 22, 25, 27, 32, 33, 38, 42, 47, 49, no place could ever be found to take one other who was adjudged ready for parole) at one time or another. Of this number, 4 (cases 4, 13, 21, and 38) did not find it necessary to return to the institution up to the present date (11/10/50), about 3 1/2 years later. Of the 12 who subsequently had to be readmitted, 7 (cases 2, 7, 19, 22, 25, 27 and 49) came back temporarily

but are now back in the community, one case (19) dying of pneumonia contracted while out of the hospital. It should be clearly understood in considering the above that only release is considered, no adequate other objective measure of improvement being thus far available. It is to be further emphasized that release is not necessarily synonymous with any of the interpretative or impressional estimates of "improvement" commonly encountered.

2. In the second place it was found that, in the patients in this series, topectomy need not produce any easily detectable permanent degradation in any sphere of function in order to effect a return to society. Moreover, if any undesirable changes from the prepsychotic personality of returned individuals were observed by their relatives, such changes have not been reported to us.

3. In 2 cases in which topectomy had failed to produce any notable changes and lateral transcranial lobotomy was subsequently performed, no improvement was encountered. Results at variance with this have been obtained elsewhere and it is not implied that lobotomy will never "improve" a topectomy failure. The point made here is that if topectomy is a failure the opportunity for "improvement" with lobotomy must also be regarded as somewhat reduced though not as a consequence of the topectomy.

4. Finally, the mortality rate of topectomy was zero and the incidence of the establishment of a convulsive pattern no greater than that reported up to that time after lobotomy. From these observations it might be logically concluded that if psychosurgery is necessary, topectomy is probably preferable to lateral transcranial lobotomy with the possible exception of such cases where functional degradation is deliberately sought.

Other than the above, the results of the first Columbia-Greystone project were of such a nature as to simplify many common speculations about frontal lobe function.

Let us now consider critically the implications of the above findings, bearing in mind that of the individuals allowed out of the hospital throughout the study, 5 were unoperated (one of these returned), that in one who recovered following operation only the superior cerebral veins were ligated and no cerebral tissue was removed (the reason for this procedure, hereinafter referred to as venous ligation, is given on page 23 of Columbia Greystone Associates, '49). Twenty-three cases received topectomies (or gyrectomies, 3 cases), 8 received lateral transcranial ("prefrontal") lobotomies, 2 of which were done after topectomy, and 2 received transorbital lobotomies.

IS THE OPERATION DIRECTLY RESPONSIBLE FOR THE RECOVERY?

THE PROBLEM OF DISCHARGE WITHOUT SURGERY. In order to evaluate any therapeutic procedure we must obtain a clear understanding of what factors may operate to produce "improvement," or the

Patient No	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	Mos institutionalized	Metrazol treatment	Shock treatment	Insulin treatment
2																77			+
3									14• 19•							82	19		14
4															[23]	9		23	
6										[43•14•]					(6 5•26)	25	14	26	114
7											12 15	(22•8)	(1•20)			23		43	35
8													39•16		[7]	40		33	39
13		•												47•16	[9•20]	21		36	56
18													[35•12]			47		12	39
19									[17•]							100			17
21	Previous	admission	5mos 1926-7													170			
22													11•			12			11
24							[28•]									153	28		
25														2		17		21	
27															[55•13] +	53	•	13+	53
31										28•15						22		15	28
32						22•										43	22		
33													20 42•		[14]	22		34	42
36														12	5? 5?	12		22?	
38												9•9				26		9	9
40													[3•]		[15•]	17		1	41
42	Previous	admission	6mos 1928 9													67			
44												(57•28+6•)				56	+6	28	37
47											[41• 20+12•]					64	+12	20	41
49	Previous	admission	1 year 1929 30													152			

FIG 1 Pre- and postoperative record of institutionalization of the 24 operated individuals in the first Columbia-Greystone project. (Top) Preoperative, (bottom) postoperative record (as of 2/15/50) Notice that several of the cases, notably numbers 2 and 44, were reoperated at a later date. Simple arabic numbers in preoperative period of institutionalization—electroshock treatments Arabic number with asterisk—insulin, arabic number followed by black circle—metrazol. Numbers not in box or circle—treatment was effectual. Encircled numbers—treatments exerted less than the desired effect. Boxed numbers—treatment was ineffectual. ?—additional unrecorded treatment believed given +—exact number of additional treatments given unknown The death of case 24 is discussed in Columbia Greystone Associates ('49). Case 33 died 8/28/49 of cavitating pneumonic disease which may have been either of acid-fast or non-specific etiology The onset of the condition was about 3 weeks earlier. No autopsy was obtained. (Preoperative record from, "Selective Partial Ablation of the Frontal Cortex," by The Columbia Greystone Associates, Fred A Mettler, Editor, New York, Paul B Hoeber, Inc , 1949)

OPERATED CASES

Pt No	July 1947 – January	January 1948 – July	July – January	January 1949 – July	July – 1950 Feb	Mos. institu- tionalized
2	L		E			31
3	TV TV	TV				26
4	TV	T	P			10
6	UN R		TV			31
7	TV TV	T TV TV		TV		23
8			TV			31
13	TV	T				10
18						31
19	TV		TV		12/?/49 DECEASED	14
21	TV	T	P		D	10
22	TV		P		D	18
24	11/19/47 DECEASED					4
25	TV	T	P		D	10
27	TV	T	P		TV	20
31						31
32	P	TV				31
33	TV	T TV			8/29/49 DECEASED	19
36	TV					31
38	TV TV	T	P		D	9
40						31
42	TV	T TV TV TV	P		D	10
44	L					31
47	TV	S				31
49	TV TV	T TV	P		D	9

TV — Trial Visit T — Return for Testing P — Parole D — Discharged UN R — Unilat Reop S — Shock Therapy L — Subsequent Lobotomy

Patients No	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	Mos Institutionalized	Metrazol treatment	Shock treatment	Insulin treatment
1	Previous admission		6 mos 1915-1918							[6]						101		8	
5														31• 10	[31• 11]	21		21	62
9	Previous admission		18 mos 1928-1929							3?	[9•(2)]	6	3?			61		21?	9
10	Previous admission		2 mos 1928						[15• 30•]	[10]						153	15	10	30
11												16• 13	8• 6	[27•]	[29]	26		48	51
12																25			
14									[3• 5•]							80	5		3
15																121			
16																109			
17	Previous admission other hosp 1906															183			
20											(19• 14)		(12•) (23• 18)			30		32	54
23												[28•]				29			28
26													17• 12	[6 R•]	[36]	30		48	85
28														30•3 [19]	+	28		21+	30
29															11+ (4 •20•)	41	20	14+	86
30	Previous admission		9 mos 1919-1923-1924													183			
34															(10)	13		10	
35																17			
37													(38 / 7?•)			34		38	32
39	Previous admission		12 mos. in 1924 1925							14 / 29•			(41• 33)			59		47	70
41							(10•)									126	10		
45												14 / 31•	[72• 20]			61		34	103
46								37•18•								33	18		37
48																67			

CONTROLS

FIG. 2 Pre- and postoperative record of institutionalization of the 24 "control" individuals in the first Columbia-Greystone project. (Top) Preoperative record of the control group, (bottom) "postoperative" record For superscript symbols see legend of Fig. 1. Numbers not in box or circle—treatment was effectual. Encircled numbers—treatments exerted less than the desired effect. Boxed numbers—treatment was ineffectual ?—additional unrecorded treatment believed given. +—exact number of additional treatments given unknown. It is to be observed that several of these patients (cases 5, 11, 20, 23, 26, 28, and 46) were operated 5 or more months after the operations shown in Figure 1. (Preoperative record from, "Selective Partial Ablation of the Frontal Cortex," by The Columbia Greystone Associates, Fred A. Mettler, Editor, New York, Paul B. Hoeber, Inc , 1949)

CONTROL CASES

July 1947 – January 1948 – July – January 1949 – July – 1950 Feb

Pt No	Events (July 1947 – Feb. 1950)	Mos. institutionalized
1		31
5	L, T TV, T P	7
9	S4, TV, T, S4	27
10	L	31
11	L, T	5
12	TV, P	13
14		31
15	TV, T P	3
16		31
17		31
20	L, T, T TV, P, LYONS HOSPITAL	12
23	L, TV	31
26	P / L	21
28	TV, L, TV, TV, TV, TV	30
29		31
30		31
34	P, T T, T	1
35		31
37		31
39	TV, TV, TV, T TV, P	2
41		31
45	S	31
46	L, TV, T TV, TV	28
48		31

TV—Trial Visit T—Return for Testing P—Parole S—Shock Therapy L—Subsequent Lobotomy

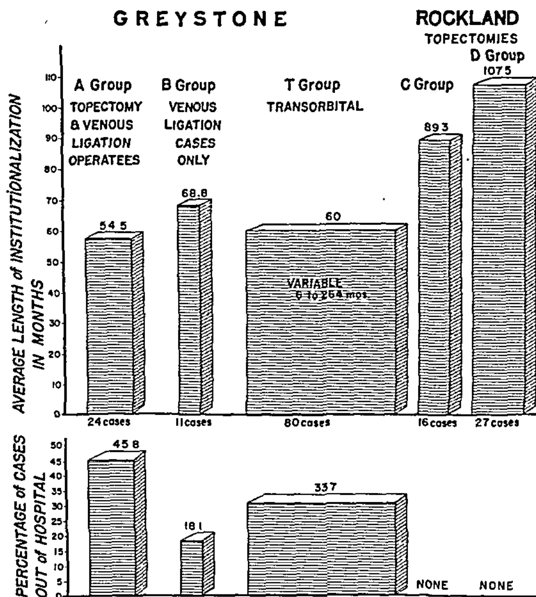


FIG. 3. Record of institutionalization and number of cases returned to the community (to 2/15/50) from 5 groups of cases. A and B Schizophrenics, chiefly hebephrenic, C "Involutional" or paranoid schizophrenics, D Schizophrenics, chiefly hebephrenic, T Variable, chiefly schizophrenics.

appearance of it, which "improvement" is entirely unrelated to that aspect of therapy upon which the observer's attention is fixed. It is well known that the rate of "improvement," even among patients who are ill enough to be committed to mental institutions, is not inconsiderable during the first year of institutionalization. Our operated patients had histories of having been institutionalized prior to 2 years before operation and beyond this length of time the rate of discharge is relatively low (about 10 per cent, which is principally made up from

diagnostic categories other than schizophrenia which was the condition nearly all our patients were considered to have). Nevertheless, it has been possible to discharge 4 patients (one of these had been institutionalized for a briefer period than 2 years) without surgery, 3 of whom have now been out for nearly 3 1/2 years. There appear to be several reasons why such a discharge is possible in cases who have been institutionalized long enough to be considered "hopeless."

1. Previous Change. As just pointed out, some individuals improve spontaneously (even as long as 10 years after admission, Boltz, '48), and, in large hospitals it is possible that this improvement may be missed unless there is an energetic and periodic restudy of all cases in the hospital.

2. Alteration in the Environment. The presence of an individual in an institution is not a measure of absolute inability of such an individual to live outside. It may merely indicate that the individual was unable to cope with the particular environmental situation from which he was committed. Alteration in that environmental situation may render it feasible for the individual to function effectively anew.

3. Alteration in the Patient. It is possible that there may be a few individuals whose morale can be raised sufficiently by a procedure such as "total push" to the point at which they can make enough of a readjustment to resume their places in society, but it is clear that at least some of the past credit which has been given to "total push" should be accorded the 2 factors just mentioned.

Some less obvious ways in which the above-mentioned principles operate in actual practice are worth mentioning. With the exception of one group, in all of our recent projects the patients who have been selected have been pretty generally considered to have had very remote chances for "spontaneous" recovery and to be very refractory to therapy. Nevertheless, definite differences do exist even among such so-called "incurables." These differences are to some extent expressible by the use of prognostic ratings but, in practice, the differences are likely to exceed the expectation based upon the prognostic rating. While the present study was in progress the Brain Research Project of the New York State Associates was also in effect. Although there were some differences in the prognostic ratings of the cases in the first and second Columbia-Greystone and New York State Projects (the psychiatric disciplines in the 2 latter projects were identical) the rate of discharge in the New York State Project among patients awaiting surgery (circumstances made it necessary to hold these patients for a protracted period prior to surgery) and controls was much lower than prognostic ratings would have led one to expect. (As of February 15, 1950, 15 1/2 months after the average date of make-up of the groups on October 1, 1948, only 5 such cases had been placed on convalescent status out of a possible 92.) Moreover, out of 43 project patients operated in the Psychiatric Institute of New York between June 24 and December 1, 1949 none had been discharged by February 15, 1950. Such circumstances might conceivably have been

due to a lessened alertness on the part of the staff at Rockland, but if the staff at Rockland were in the habit of neglecting to discharge suitable cases it would show up in other records of the hospital. Examination of the general records of Rockland and Greystone shows no notable difference in the rate of discharges (see Table 1) which is about 25 per cent. Rockland gets a greater proportion of "new" cases and has a higher proportion of readmissions from recent discharges. Both

Table 1

COMPARISON OF CERTAIN DATA ON DISCHARGE AND READMISSION IN THE ROCKLAND STATE HOSPITAL AND THE NEW JERSEY STATE HOSPITAL AT GREYSTONE PARK*

	Rockland	Greystone
A. Number of admissions for the year 1948	1646	1842
B. Number of patients in hospital Jan. 1, 1948	6545	5471
C. Number of patients in hospital Dec. 31, 1948	6526	5541
D. Number of patients discharged from hospital from Jan. 1, 1948 to Dec. 31, 1948	1617	1337
E. Number of patients who were discharged in 1948 and readmitted prior to July 1, 1949	698	405
F. Number of patients who were discharged in 1948 and had not been admitted to a mental hospital prior to Jan. 1, 1947	1245	769

* The number of patients in hospital (B) excludes any not physically in institutions, excepting those out for the purpose of a holiday (or similar) visit. The word "discharged" (D) includes those patients out on trial visit, on parole, or in family care, but not removal due to death, escape, transfer to another institution, or a "social" visit—such as over a week-end or holiday. It does not include patients not physically in hospital at the time of the "discharge" whose status was merely altered on the records. The word "readmitted" (E) refers to return to the hospital for purposes of care for any period whatsoever. Cases readmitted for test purposes only are not considered readmitted.

With regard to the data from Rockland, since theoretically the expected residual hospital population of December 31, 1948 (the total of A plus B minus D) is 48 more than the actual population (whereas because of 338 deaths and several escapes, it should be smaller) it is apparent that some 380 of the cases discharged in the period under consideration had to have been readmitted during the year. Actually an 18-month period is a better measure of such readmissions which totaled 698 (E) or about 30 per cent. Of the 1617, (1948 discharges) 1245 or 76 per cent were "new" patients who had not been in a mental hospital before 12 months prior to the period under investigation. Since the differ [illegible]
of these new cases probably [illegible]

In comparing the data f[illegible]
admissions and readmissio[illegible]

hospitals return about the same proportion of cases to the community. In New Jersey the cases that are admitted contain a larger proportion of "old" patients who were in the hospital before. At Rockland, on the other hand, the readmitted cases have evidently relapsed faster and released patients apparently do not long remain in residence in the area supplying that hospital. It is apparent that Rockland does in fact release patients as readily as does Greystone and this cannot be used to explain the differences in results.

As indicated above, the rate of discharge varies inversely with the length of institutionalization and in the present case such an inverse relationship was again observed. Thus figure 3 indicates that the period of institutionalization was appreciably longer for the C and D (Rockland) groups than for the A and B (Greystone) groups. This observation is in line with what we know about the general relationship between duration of institutionalization and opportunity for recovery. However, as has been pointed out above, a long average period of institutionalization by itself should not reduce the rate of improvement, even without the use of any therapy, to a level so far below the average performance of the hospital as was observed in the cases at Rockland and it becomes necessary to search further for differences between the patient groups. When this is done an interesting fact emerges. Cases in the B, C, and D projects were chosen from a population that had remained at the institutional level more consistently than had the first group of Greystone cases. Thus, among operated cases only, the 24 cases in the first Greystone project had 41 interruptions in their records of hospitalization, whereas the 27 operated cases in the B group had but 26, the 16 operated cases in the C group had 8 such interruptions, and the 27 operated D cases, 39 breaks. It is obvious that there must be fundamental differences between a population that remains almost uninterruptedly in a mental hospital and one whose stay is occasionally interrupted by periods of return to society. Whether the latter circumstance is due to variation in the patient or in his environment does not matter—the long-run implication is the same, notably that it is more difficult to return patients with static records to the community. It is concluded that there is no such thing as a "hopeless" patient and that one must remain constantly on the alert to prevent spurious factors from raising figures on "improvement" accredited to the use of specific therapies. On the other hand, vigilance is also necessary to take advantage of any promising postoperative swings on the part of the patient in the direction of improvement in order to find out whether he can now function satisfactorily within the community. Factors, as an occluded home situation which obstruct prompt trials outside the hospital, are bound to produce spurious lowering of the "improvement" rate.

In the present study a strong effort to eliminate the possibility of spontaneous improvement was made by selecting 33 cases (see fig. 7) who had an average period of institutionalization of 70 months as compared with 54 1/2 months for the A group and a lower number of

due to a lessened alertness on the part of the staff at Rockland, but if the staff at Rockland were in the habit of neglecting to discharge suitable cases it would show up in other records of the hospital. Examination of the general records of Rockland and Greystone shows no notable difference in the rate of discharges (see Table 1) which is about 25 per cent. Rockland gets a greater proportion of "new" cases and has a higher proportion of readmissions from recent discharges. Both

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F. Number of patients who were discharged in 1948 and had not been admitted to a mental hospital prior to Jan. 1, 1947	1245	769

* The number of patients in hospital (B) excludes any not physically in institutions, excepting those out for the purpose of a holiday (or similar) visit. The word "discharged" (D) includes those patients out on trial visit, on parole, or in family care, but not removal due to death, escape, transfer to another institution, or a "social" visit—*such as over a week-end or holiday. It does not include patients not physically in hospital at the time of the "discharge" whose status was merely altered on the records.* The word "readmitted" (E) refers to return to the hospital for purposes of care for any period whatsoever. Cases readmitted for test purposes only are not considered readmitted.

With regard to the data from Rockland, since theoretically the expected residual hospital population of December 31, 1948 (the total of A plus B minus D) is 48 more than the actual population (whereas because of 338 deaths and several escapes, it should be smaller) it is apparent that some 380 of the cases discharged in the period under consideration had to have been readmitted during the year. Actually an 18-month period is a better measure of such readmissions which totaled 698 (E) or about 30 per cent. Of the 1617, (1948 discharges) 1245 or 76 per cent were "new" patients who had not been in a mental hospital before 12 months prior to the period under investigation. Since the difference between F and D is 326 less than E, about a quarter of these new cases probably returned to a hospital within the next year and a half.

In comparing the data from the 2 hospitals we see that the proportion of "new" admissions and readmissions from discharges at Greystone are both less than at Rockland. The population in the area would therefore appear to be less labile and the cases admitted would appear to show a greater degree of chronicity. There is no statistically significant difference between the institutions in rates of discharge.

of "recovery" but also the "recoveries," viewed from the vantage point of the present time, have tended to predominate among those cases with the best prognostic rating. If one bears in mind not only the care-

NUMBER of CASES	CASE NUMBERS								
13						[49]			
12						44			
11						[38]	[38]		
10						36	32		
9						33	31		
8	49					32	27	[38]	
7	36					27	[25]	32	
6	33					[25]	[22]	27	[38]
5	[25]					[22]	[13]	[25]	27
4	[22]	36			49	[21]	8	8	24
3	[13]	33			[42]	13	7	7	6
2	8	[19]	47		36	8	3	6	3
1	[4]	[13]	33	40	18	7	2	2	2
AREAS	46	45	44	24	11	10&47	9	8	6

FIG. 5. Number of times particular areas were removed in individual cases. Boxed case number indicates operatees out of the hospital. It is obvious that the occurrence of a large number of "recoveries" in the 9 and 10 categories might mean nothing more than the continued operation of the factor of pure chance.

ful restrictions placed upon the cytoarchitectural studies but also recalls that the number of cases in each category of removal varied (fig. 5) there is certainly no indication from these cases to support the belief that "recovery" is specifically related to removal of areas 9 and 10 (Heath and Pool, '48; LeBeau, '48; LeBeau, Bouvet, and Feld, '48; LeBeau, Bouvet, and Rosier, '48; Pool, Heath, and Weber, '49; Schlesinger, '50). Moreover, it is by no means quite certain that the operative procedure is correlated with improvement. The significance of the fact that the number of operated cases discharged from the first Columbia-Greystone project is greater than the number of discharged controls is obscured by the difference in prognostic expectation between the 2 groups. It is clear that there is a positive correlation between the "improvement" of the "improved" operated patients and the occurrence of the project and, perhaps, the incident of operation but the possibility that the "improvement" of these operated cases is related to something in the project situation other than the operation must be kept in mind as we proceed. In any case we may construct several propositions which, if followed, should ensure safe psychiatric treatment.

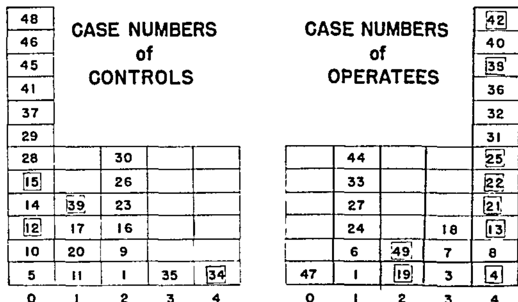


FIG. 4. Prognostic expectation of cases in the first Greystone series. On the abscissa, 0 represents the worst and 4 the best prognosis. The numbers forming the units in the distribution curve are those of the particular cases. The boxed numbers are those of cases who have stayed out of the hospital, after the original operation, or, (if in the control group) without subsequent operation.

breaks in preoperative hospital residence (17 of 33 patients exhibited 31 such interruptions).

In attempting to arrive at any estimate of what degree of effectiveness psychosurgery may have, it is, of course, necessary to develop prognostic expectations by using a great variety of criteria (in addition to duration of institutionalization and frequency of remissions) for controls and operatees and to take these into consideration in evaluating whatever results are obtained. Just what factors should be used in arriving at a prognostic rating are not yet clear however. The following factors have been considered—diagnosis, nature of and age at onset of illness, response to previous shock therapy, subjective "impression," absence of "painful" affect, degree of "deterioration," and length of institutionalization. In the present study the psychiatric discipline also attempted to evaluate the prognostic use of "Amytal interviews."

Reference to figure 4 will show that in the first project the expectation for the control group was distinctly different from that of the operatee group. The existence of this difference and the reasons for it were explained in Columbia Greystone Associates ('49, see p. 22) but the question now arises as to whether the rate of "recovery" among the operatees represented anything more specific than might be expected to occur spontaneously in a group with the record of institutionalization discussed and upon a prognostic basis alone, for it is certainly true that not only was the group of operatees weighted in favor

HEREDITY AND ORGANIC DISEASE. Our original series included patients both with and without a history of definite psychiatric illness in their blood relatives and it is possible that such a circumstance may influence the results obtained. It is, of course, impossible to obtain a group of cases in which one can be certain that no psychoses exist or existed in the blood line but it is possible to set up 2 groups for study—one with definite history and one without. If all other variables can then be adequately controlled, and if there is a statistically significant difference in the subsequent behavior of the groups, one can be certain that heredity exerts a definite influence on the course of events. The same reasoning applies to the existence of organic brain disease, or lack of it, and in selecting the present series of cases consideration of both these factors was included in the screening procedure.

SHOCK AND COMA. Since convulsive and coma therapy may induce more or less specific alterations, the amount of such preexisting drastic therapy must also be evaluated by consideration of groups intensively and lightly so treated. Since the administration of this therapy is common, and since it is varied in a specific rather than random nature, such an evaluation may prove very difficult if not impossible to attain.

VARIATION IN DEGREE OF INTEGRATION. Perhaps the most serious complication in our initial study was the obvious inequivalence of the patient material—some of the individuals presented an appearance of satisfactory integration of personality—others were obviously seriously deteriorated. As previously pointed out we were well aware of the existence of such variations and have explained how they came about. In fields such as psychology, if deterioration is profound, the gathering of profitable data may be impossible. In our previous series the inequivalence in patient material, referred to above, vitiated our ability to speak with any degree of assurance about the non-effectiveness of certain operative procedures. We have already pointed out that the apparently relatively high score of area 9-10-46 topectomies may be entirely spurious as a result of the weighting factors inherent in the selection of cases for operations in these regions. This statement should not be interpreted to mean that 9-10-46 ablations of areas 9, 10, and 46 did not eventuate in the results reported but rather that ablation of other regions may have failed to produce equally good results because of the poor nature of the case material on which *other* topectomies were done. Naturally, the present writers would be expected to exhibit a bias in favor of operations in the region of area 9 since it was previously pointed out by one of us that this cytoarchitectonic area when removed alone (or disconnected by means of an area 6 ablation) resulted in definite behavioral differences in simians (Mettler, '44, see conclusion 16, p. 131). It was for this reason that area 9 was selected for the original pilot operations. Since we are aware of

Proposition 1. No patient should be subjected to any form of therapy involving the possibility of danger until the case has been thoroughly and repeatedly restudied in a versatile manner. (Much could be said about the nature of this restudy which will obviously be useless if casual, or confined to one particular method of approach, but it will suffice to emphasize here that it must be conducted over a protracted period and that any signs of improvement must be followed up.)

Proposition 2. No patient should be subjected to any form of therapy involving the possibility of danger until strenuous efforts have been made to readjust the environment for him.

Proposition 3. No patient should be subjected to any form of therapy involving the possibility of danger until all means to rehabilitate him by less drastic therapy have been exhausted.

It is clear that practical considerations will often accelerate and curtail attempts to use techniques that are slow but it would be dangerous to adopt the principle that slow methods which are only occasionally effective should be discarded because they are laborious and time-consuming.

THE PROBLEM OF DISCHARGE AFTER VENOUS LIGATION. The initial series of operated cases included one (case 38) who was discharged and who has remained out, without untoward developments, following ligation of the superior cerebral veins and without ablation of cortical tissue. Experience with this case recalls to mind that recoveries have been reported by others in several cases in whom lobotomy was attempted and abandoned after abortive surgical efforts, or in whom evidence of the surgical significance of lobotomy was poor, following the death of supposedly successful lobotomized patients. Since the question of the non-specific effects of surgery upon a psychosis is always raised by cases showing some degree of improvement, it became a matter of importance to elucidate the possible *mechanism of improvement in case 38. Since this case showed no* evidence of improving during the preliminary study period it may be concluded that the probability of her discharge being due to spontaneous recovery was slight. Such an opinion is fortified by the subsequent favorable and uncomplicated course of the case. In the present study 12 additional cases of venous ligation were studied.

The results of our first study indicate that discharge of at least 10 per cent of cases institutionalized on the average for a period of at least 3 years can be effected without psychosurgery or other specific therapy (the actual figure for that project is 16 per cent) and that an additional 20 per cent or more can be gotten out by the use of psychosurgery (the actual figure for return to the community 3 1/2 years after topectomy alone is 43.4 per cent). Our first study does not clearly indicate which frontal areas are ineffectual if removed, neither does it exclude a non-specific operative effect. Venous ligation may be anticipated not only to involve maximal areas but also to produce the maximum number of non-specific effects which might be expected to follow an intracranial operation.

THE SEARCH FOR IMPROVED METHODS OF THERAPY

In our first monograph we pointed out that development of an operation, although a useful object was not our primary goal. What we wanted to know and what we still want to know is why patients improve following psychosurgery and how to manipulate the causes for such improvement in the most expeditious manner and with the least danger to the patient. One may search for such causes in at least 3 principal spheres of investigation—the physiologic, psychologic, and psychiatric.

In the physiologic sphere we have not found that ablation of areas of granular frontal cortex produces any very obvious enduring alteration, the development and persistence of which parallels the improvement of the patient. If the patient's improvement is related to physiologic (in the conventional sense of the word) changes, these are evidently of a very subtle type or are masked by homeostasis. Some very obvious changes, such as increase in weight, are either inconstant or not directly related with the improvement or possible causes for it. Apparently we either had to carry our investigations in this field into deeper and narrower channels or employ new physiologic methods. In the present investigation we favored the latter approach and repeated only those physiologic studies previously employed which were necessary to provide continuity between the 2 studies.

In the sphere of psychologic measurements the effects of such operations are also far from obvious. There was a clear, positive correlation between social recovery and decrease in both anxiety and complaint scores. The fact that anxiety and complaints should decrease in close correspondence to social recovery is of interest but does not shed too much light on the basis of the improvement. The loss-followed-by-gain in mental age as evidenced by the Porteus Maze test in patients that showed social improvement was unmistakable but the meaning of the pattern of change is unclear. The loss-followed-by-gain in critical flicker fusion (when the CFF was above a certain critical figure) in patients who showed social improvement suggests that more precise and definitive psychophysical measures of sensation and perception might give clues to the neural basis of recovery, but this particular observation had to be corrected for relations between stimulus strength and frequency. (Is there, for example, as a result of the operation, an alteration in the patient's ability to perceive the intensity of the stimulus—as a result of paresis of the intrinsic or extrinsic muscles of the eye—which is reflected in an alteration in critical flicker fusion?) All these points—and several others as well—furnish clear indication that the psychologic investigation had to be extended in an intensive fashion.

Psychiatric improvement after psychosurgery may be differently defined in terms of certain rating scales, the validity of which is itself subject to investigation because of the subjective element in these scales and their tendency to be weighted by the very hypotheses they

this incubus and since preconceptions, if accompanied by success, easily spread to others it is clear that further study of granular cortex other than areas 9, 10, and 46 is definitely indicated and for such study to be meaningful the case material must be grouped in statistically significant numbers into some sort of distinct psychiatric categories and equated in terms of education and psychologic accessibility.

THE PROBLEM OF THE PATIENT'S ENVIRONMENT. We have pointed out above that a patient's presence in an institution is only a relative measure of his psychiatric condition. Any institutional psychiatrist knows that he could discharge a large number of his charges if he could create a special environmental situation tailored to suit the needs of each patient. It does not follow because a patient is discharged that his psychopathology is fundamentally altered. There is, however, considerable danger in leaning so far in an opposite direction that no patient is considered improved if evidences of psychopathology can still be discovered. In a situation such as this, psychiatry is badly in need of some sort of objective scale such as cardiologists use to express degree of compensation. Knowledge that a patient, who can live outside an institution, still displays psychopathology should not be treated as any more damning than the knowledge that a person capable of limited but useful activity harbors a quiescent lesion. Since quantitative estimation of the degree of psychopathology presumed to exist is difficult and its assessment is largely an impressional matter it is apparent that definite criteria for improvement require to be developed. An attempt was made in this direction in the "social improvement scale" of the first project but this still leaves much to be desired.

Perhaps the most comprehensible measure of improvement of a patient is his ability to return home. However, if return to the home environment is the yardstick by which the patient's improvement is to be measured, one must be certain that this environment retains the same qualities it had when he left it. Since this is never the case, our next best method of standardizing the measure is to be certain that the patient has some sort of supportive environment into which he can be received.

In our first series of cases we fell squarely athwart this obstacle. Some patients who the present writers, at least, felt might very well function in a moderately supportive environment, were met by rejection by their families. Others who seem essentially unchanged were, either by the alchemy of the social service workers' touch or as a result of parental remorse, converted into discharges. If one evaluates patients in terms of discharge and ability to retain gainful employment the estimate is rendered more meaningful but the process of evaluation is complicated by the nature of the employment and by the fact that females or cases admitted early in life may never have had any gainful employment.

which might prove distinctly superior to what we have under study, and several cases of transorbital lobotomy were included in this study, as well as 2 cases of a modified form of thalamotomy.

WHAT WAS DONE IN THE PRESENT STUDY

PROCEDURE FOR SCREENING TO ELIMINATE CERTAIN CONTROLLABLE VARIABLES. In order to rule out some of the difficulties mentioned above we adopted a screening procedure which tended to eliminate from the operative series (1) cases in whom spontaneous improvement might be expected to occur, (2) cases with a positive psychiatric history in the blood line, (3) those who presented medical complications, language difficulties due to unfamiliarity with the American idiom of speech, and (4) such cases who were inaccessible to psychologic testing. This screening procedure was also designed to narrow the degree of psychiatric variation in the cases chosen and to eliminate from the operative group such individuals who had no satisfactory environment to which they might return if improved.

The plan for screening (and the figures resulting, which may be of interest in computing the possibilities of future patient samples) was as follows: (1) selection of possible cases by survey of the entire patient population of the area of activity, (2) psychiatric screening, (3) psychologic screening, (4) social service survey, and (5) obtaining of operative permits.

We have learned that it is a serious error to select cases from too small a raw group or to begin definitive preoperative study before it is clear that no major obstacle exists to the further development of the case. Accordingly, it is wise, after deciding just what type of patient *one expects to study, to survey several thousand records (one* may just as well do all the records of a hospital) to arrive at the names of all the probable candidates. If business machines exist for doing this, so much the better, otherwise it must be done by hand. For the present study all the records of Greystone were surveyed (beginning May 17) by Miss Dorothy Logan and those meeting the following criteria were laid aside:

Schizophrenics and psychoneurotics in the age group from 25-35 and involutionals and manic depressives in the age group from 45-55 (this age group also included paranoid schizophrenics, see below)

who had

graduated from grade school in the United States,

been ill for at least 3 years without remission (figures 7 and 8 show that this criterion was violated in cases 5, 12, 15, 21, and 25)

received all indicated therapy and

a presumably satisfactory home to which they might return if they improved

but who had no history of obvious psychosis in the blood line

are designed to test. Improvement may also be defined in terms of the patient's own report of his subjective state. In evaluations of the latter type, relief from anxiety is probably the feature to which most weight is customarily attached. It is obvious that in operations such as lobotomy, relief from anxiety can be carried to the stage of irresponsibility and casual behavior. Assuming that such relief from painful affect exists, what is its nature? Is it the first stage in a process of deterioration? If so, why is it so difficult to detect any evidence of impairment of function in the psychologic sphere in "improved" topectomized cases? In animals there is evidence that ablation of granular cortex tends to "externalize" the organism (Mettler, '44) and Halstead ('47) has reported "stimulus-binding" as a sign of brain damage. It is interesting to observe that operative procedures which decrease an animal's contacts with the external world (as, for example, blindness) tend to render it intractable, whereas operative procedures which impair motor ability often turn intractable beasts into animals that can be handled with a degree of ease which is quite out of proportion to the slight motor disability which may have been induced. Has the frontal region in man developed to a degree in which the anxiety factor has become somewhat disassociated from the motor mechanism? Are speculations of such types of any use in pointing out in what psychotic conditions granular ablations are likely to be most and least useful? It would appear that in the field of psychiatry, further investigation and analysis of the factor of anxiety is definitely indicated.

From a technical point of view topectomy leaves much to be desired. It is clear enough from our previous study of the cytology of the site of previously performed ablations that the pathology of the operation is not restricted to the region removed. There is more or less extension of cellular loss beyond the operative site and this loss of cells is confined, in some areas at least, to the layers of cortex supplied by the supracortical arterial capillary plexus (layers I-III, loss of which figured prominently in speculations of earlier days about the cause of the euphoria of cerebral syphilis). The question may well be raised as to whether some of the beneficial effects observed are due to the localized removal or to the much wider, concomitant loss of supragranular cortex. It is apparent that if the latter is the case the localized ablation may be unnecessary. In order to obtain some information about these matters, an application of the method of thermocoagulation was developed.

Again it would be an error to develop such a restricted perspective as to ignore parallel developments by others in the field of psychosurgery. Since we began our original studies, transorbital lobotomy became a widely employed operation and thalamotomy was described. We could not, of course, be diverted into many tangential enterprises and it is largely up to those who introduce new approaches to do the work necessary to develop and validate these but we did have the obligation of directing a certain amount of attention to any procedure

Psychiatric screening was now introduced in order to determine the exact, present condition of the patients, in order to check the duration of the illness and absence of remissions and to eliminate completely deteriorated cases. The number of cases was reduced by this procedure to the following figures: involutionals (this classification, after closer study of the cases, was now changed on this group to schizophrenia, paranoid) 10; and schizophrenics 30. A technical detail of small psychiatric value, but a useful time-saver in a project such as this, has been to have psychiatry take the responsibility for (1) checking the correct spelling of the patient's name, (2) the accuracy of the age and marital status, (3) the genetic history, (4) the peak of educational attainment, (5) the peak of prepsychotic occupational performance, (6) the duration and dates of institutionalization, and (7) the extent and dates of coma and convulsive therapy. Checking of items 5 through 7 can profitably be deferred until the screening procedure is complete but in order to avoid extensive corrections of developing records, the first 4 items should be verified early.

Psychologic screening was next introduced in order to insure testability. After this and medical screening the group had been reduced to 7 involutionals (schizophrenia, paranoid) and 23 schizophrenics.

Since this number of cases was already below the upper limit of our facilities the obvious further reduction which would result after evaluation of the home environment, and from the attempt to obtain permits for operation, would serve to split off a number of cases suitable for inclusion in the project as unoperated controls and preoperative study was ready to proceed.

Accordingly, the remaining 30 cases were all transferred on August 14, to our test ward and definitive preoperative study was begun on August 16, in accordance with a standard flow chart like that shown in figure 1 of our first monograph (Columbia Greystone Associates, '49).

THE EFFORT TO IMPROVE THERAPY

It is apparent that the group we had at hand was far too small to provide us with enough material to determine whether removal of certain areas of the granular cortex is more effective than removal of others, or to determine whether removal of different granular areas is of variable effectiveness in different psychiatric conditions. Only enough material was at hand for providing a statistically significant answer to one or 2 questions. By the time the social backgrounds of the patients had been analyzed and the necessary permits obtained, our operative material pool consisted of 24 cases. A psychiatric grading (from 1 to 4) with the lower numbers for the better prognoses was now requested in order to get a somewhat better idea of the relative severity of degradation of the patients. The results for the patients for whom supportive possible postoperative environments were found is shown in Table 2.

organic brain disease or
other chronic systemic disease.

The number of records selected was as follows: psychoneurotics, 0; manic depressives, 4; involutionals, 16; and schizophrenics, 70.

BASIC DATA FOR PATIENTS IN SECOND COLUMBIA-GREYSTONE PROJECT GROUP B

Group	Patient's Number	Age	Sex	Marit. Cond.	I.Q.	Occupation	Final Preop Diagnosis	Date of Op Oct 1948
VENOUS LIGATION 12	B1 - 41244	33	F	S	90	PHOTO FINISHER	SCHIZ HEB	4
	B2 - 38574	33	F	Sep	102	COMPTOM OPER	CAT	4
	B3 35775	34	F	S	89	STENOGRAPHER	HEB	5
	B4 38661*	50	F	M	97	DOMESTIC & WAITRESS	PAR	5
	B5 46658	51	F	M	97	FACTORY WORKER	PAR	6
	B6 39052	32	M	S	100	DAY LABORER	CAT	6
	B7 44646	35	F	S	85	DRY CLEANER	HEB	7
	B8 32184	47	F	M	102	FILE CLERK	PAR	7
	B9 43164	36	M	M	98	TRUCK DRIVER	HEB	8
	B10A 44961	52	F	M	114	STENOGRAPHER	PAR	8
	B11 44403	32	F	S	88	LAUNDRY WORKER	CAT	11
	B12 45806	26	F	S	93	CLERICAL WORKER	CAT	12
THALAM 2	B13 38272	32	M	S	96	BLDG DISPATCHER	HEB	13
	B14 41746	26	M	S	58	ODD JOBS	HEB	14
THERM 2	B15 47767	30	F	S	82	OFFICE WORKER	CAT	15
	B16 42688	30	F	Sep	73	OFFICE WORKER	HEB	18
TRANSORBITAL LOBOTOMY 9	B17 43217	33	F	M	56	DOMESTIC	HEB	28
	B18 46320	28	F	S	80	FACTORY WORKER	HEB	28
	B19 39579	34	M	S	55	MACH SHOP WORKER	HEB	28
	B20 45747	27	M	S	74*	FACTORY WORKER	HEB	28
	B21 49270	33	F	S	76	NONE	HEB	28
	B22A 33276	33	F	M	76	FACTORY WORKER	HEB	28
	B23 41463	29	F	S	82	NUN	HEB	28
	B28 38938	30	F	S	77	HAIR DRESSER	HEB	28
	A10 26023	45	M	S	76	DRIVER	HEB	28
	A8 43486	30	M	S	90	COOK	PSYCH ? INCIP ?	20
	MSH 50670	21	F	S	77	NONE	PSYCH ? SCHIZ ?	19
CONTROLS 6	B10 45441	42	F	M	86	FACTORY WORKER	PAR	
	B22 39618	36	F	M	103	CLERICAL WORKER	HEB	
	B24 42468	44	F	S	100	SALES CLERK	PAR	
	B25 47018	32	M	S	115	MARINE SERVICE	CAT	
	B26 35932	52	F	D	83	WAITRESS	PAR	
	B27 40559	28	M	S	115	NONE	HEB	

* DECEASED 10/7/48

AGE DISTRIBUTION AND OPERATIVE PROCEDURE EMPLOYED

AGE: 52, 50, 45, 42 (SCHIZOPHRENIC PARANOID DECADE); 36, 35, 30, 26 (HEBEPHRENIC & CATATONIC DECADE)

		LIGATION OF VEINS	THALAMOTOMY	THERMOCOAGULATION	TRANSORBITAL LOBOTOMY	CONTROLS
SEX	MALE	2	2	0	2*	2
	FEMALE	10	0	2	6	4
DIAGNOSIS	HEB	4	2	1	6*	2
	CAT	4	0	1	0	1
	PAR	4	0	0	0	3

* NOT INCLUDING A10 (A MALE SCHIZOPHRENIC HEBEPHRENIC OF 45 YEARS OF AGE)

COMPARISON OF GROUPS ACCORDING TO PREVIOUS HOSPITALIZATION & THERAPY

NUMBER OF CASES	MOS INSTITUTIONALIZED TO OCTOBER 1948		NO of CASES RECEIVING: METRAZOL	ELECTRO SHOCK	INSULIN
VENOUS LIGATION 12	888	(74)	2	6	7
TRANS ORBITAL 9	759	(84)	2	6	6
CONTROLS 6	433	(72)	1	2	3

FIG. 6. Basic data for B group and other cases in second Columbia-Greystone project. Average figures in parentheses

	1948					1949							
Pts no	OCT	NOV	DEC	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	SEIZURES	ADD. INFORMATION
B1							P						NONE	ADEQUATE ADJUSTMENT
B2									TV				NONE	
B3													NONE	
B4	DECEASED 10/7/48												NONE	
B5													NONE	
B6													NONE	
B7					P						R		NONE	OUTBURSTS of [illegible]
B8													NONE	
B9													NONE	
B10A					P								NONE	ADEQUATE ADJUSTMENT
B11												TV	NONE	
B12													NONE	
B13		TV							EST				NONE	
B14					E								NONE	
B15							TV L						NONE	
B16		TV											NONE	
B17		TV											NONE	
B18							TV						NONE	
B19													NONE	
B20					E								NONE	
B21		TV											NONE	
B22A					P								NONE	
B23													NONE	
B28													NONE	
A10		TV											NONE	
A6		TV											5/49 to present time	
MSH						EST 27	EST 14	EST 10 T					NONE	TRANSFERRED 5/19/49 to TRENTON STATE HOSPITAL
B10													NONE	
B22													NONE	
B24													NONE	
B25								D					NONE	IMPROVED
B26													NONE	
B27													NONE	

TV TRIAL VISIT P PAROLE D DISCHARGED R RETURNED E ESCAPED EST ELECTRO SHOCK THERAPY T TRANSFERRED T.L. [illegible]

FIG. 8. See legend of Fig. 7. Postoperative period. Case B12 was found to have evidence of pulmonary tuberculosis in July of 1949. Case MSH was transferred to Trenton State Hospital on 5/19/49.

Group	Patient Number	1936–1948	Mos. Institutionalized (to Oct 1948)	Metrazol Treatment	Electro-Shock Therapy	Insulin Treatment
Ligation	B1	Operation →	72	0	3/16/43 13	1/4/43 39
	B2		78	0		
	B3		119	6/20/40 24		
	B4*		75	3/41 2		
	B5		32	0		
	B6		93	0		
Venous	B7		35	0		
	B8		148	0		
	B9		55	0		
	B10A	Previous admissions to other hospitals	40	0		
	B11		30	0		
Thalamotomy	B12		36	0		
	B13		97	11/20/40 18		
Thermo-coagulation	B14		84	0		
	B15		18	0		
	B16		60	0		
Lobotomy	B17		55	0		
	B18		41	0		
	B19		86	0		
	B20		40	0		
	B21		24	0		
Transorbital	B22A	Previous adm. 9m., 1932	95	10/9/46 21		
	B23		70	0		
	B28		90	0		
	A10	1 Adm 9/5/28; 2 Adm 5/18/32	177	12/38 19		
	A8		47	0		
	MSH		73	0		
Controls	B10		48	0		
	B22		86	0		
	B24		91	0		
	B25		36	0		
	B26		118	0		
	B27	* Died	94	10/8/39 12		

FIG. 7. Record of preoperative institutionalization and convulsive and coma therapy in cases of the second Greystone project. Asterisk ndicates patient deceased on 10/7/48.

Since some of the ratings for certain of the diagnostic categories contain no cases and others only one case it is apparent that only one relatively representative group of 12 cases could be made up from the series which itself was entirely lacking in manic-depressive and psychoneurotic samples. Since this material was inadequate to solve the problem of the relative merits of different types of topectomy that operative approach was out of the question and attention was shifted to the 4 remaining techniques requiring elucidation, notably thalamotomy, thermocoagulation, venous ligation, and transorbital lobotomy.

THALAMOTOMY. As originally described, thalamotomy presents a number of technical problems which make its evaluation very difficult. Fifteen years of experience with the stereotaxic instrument on the part of one of us has left us with a somewhat reserved estimate of the supposed accuracy of instruments of this type. Although we have probably made several thousand placements in the course of our experimental work we have yet to finish such a placement with the expectation on subsequently finding it precisely where we intended that it should be. The generation of gas during electrolysis and interference with vessels which supply and drain regions other than those under investigation (Carpenter and Whittier '51) all tend to render the technique somewhat less precise in practice than it is in theory. In experimental work this makes little difference—one withholds judgment until microscopic study of the neuraxis confirms the placement and then one discards irrelevant material. Despite the recent studies of Meyers and Hayne ('48) it is hard to see how it would ever be possible to analyze such data with precision without autopsies. Disconnection of the thalamofrontal circuit has, however, considerable theoretical interest and, as the surgical discipline pointed out, the thalamus is directly visualized in tumor work. If ablation or disconnection of the medial thalamic nuclear mass is of therapeutic value, direct visualization is one way of being certain that such destruction or disconnection has been brought about though it has the disadvantage of producing damage beyond the thalamus. Since such an operation requires an extraordinary degree of neurosurgical skill and is not unaccompanied by danger, thalamotomy by direct visualization was decided upon for only 2 of the least promising cases (nos. B13, B14).

Footnote for Table 3—(Continued)

Rating V. Questionable or inadequate family interest or ability to help the patient or to work with hospital staff. Adequate financial background, comfortable physical living conditions for the patient.

Rating VI. Marginal home situation physically and financially. Family interest as in V.

Rating VII. No interested relatives found who will assume responsibility for receiving the patient should he improve which would mean that family care or some plan with public assistance would have to be worked out if the patient shows sufficient

Table 2

PREOPERATIVE DIAGNOSES AND PROGNOSTIC RATINGS OF CASES IN SECOND GREYSTONE PROJECT*

Rating	Schiz. Heb.	Schiz. Cat.	Schiz. Par.
1		B12	B5
2	B7, B9, B16, B21, B22A	B2, B11, B15	B10A
3	B1, B3, B18, B20, B23	B6	B8
4	B13, B14, B17, B19, B28		B4

*The lower numbers indicate the best prognoses.

Table 3

SOCIAL SERVICE RATING OF OPERATED CASES AS OF 1/14/49, ACCORDING TO ENVIRONMENTAL RATING SCALE DEVISED 9/28/48 BY HESTER CRUTCHER*

I	II	III	IV	V	VI	VII
6	7	12	10a	3	14	22a
16	2	8			9	5
	1	13			11	28
	18	19			17	A8
	A10				20	MSH
					21	23

* The Roman numerals have the following values.

Rating I. A supportive home environment, comfortable living conditions for the patient with blood relatives or spouse who seem interested in the patient and willing to accept him when he leaves the hospital. In this rating will be the relatives who have an intelligent and accepting attitude toward the patient, adequate financial background, and a willingness to work with both the medical and social service staff to promote the patient's welfare.

Rating II. A home with blood relatives or spouse where they state that they will cooperate with the hospital staff in accepting the patient if he improves. In this rating the relatives have some negative attitudes such as fear of the patient or a certain amount of controlled hostility toward him, thus making the patient's situation less promising than Rating I. Adequate financial background, comfortable living conditions for the patient would be expected for the patient who is rated in this group.

Rating III. Same as Rating II except that there would be a question as to whether or not the physical conditions of the home would be comfortable or the financial situation adequate.

Rating IV. Interested relatives who will work with hospital staff, accept the patient when he improves, and give him some support, but due to limited quarters a necessity for the patient to live outside the home—perhaps in a nearby room with the family giving supervision. Need of financial assistance for the patient may or may not be evident.

38 was introduced in the original series in order to control this common factor. It was further reasoned, originally, that venolysis might, by rerouting venous drainage, alter the critical blood flow and gaseous exchange values of the cortex drained. After it had become clear that the discharge of case 38 was stable we were placed in the position of being forced to decide whether we would continue to remove pieces of cortex (after varying degrees of obstruction of the venous drainage) or determine whether it was necessary to do anything more than simply divide the veins of the region. If we did not do this and it subsequently turned out that the latter procedure was a highly successful one we would be in the position of having encouraged unnecessary surgery and it was up to us to clarify this point at an early date. Accordingly 12 cases selected in such a manner as to take full advantage of the variables of our present series were scheduled for ligature of the frontal superior cerebral veins. These cases were as follows:

Prognostic Rating (see Table 2)	Schiz. Heb.	Schiz. Cat.	Par.
1		B12	B5
2	B7, B9	B2, B11	B10A
3	B1, B3	B6	B8
4			B4

TRANSORBITAL LOBOTOMY. In the 8 remaining cases we decided to determine the effects of transorbital lobotomy. It should be immediately pointed out that these cases (all were hebephrenic schizophrenics whose ratings were as follows: 2—B21, B22A; 3—B18, B20, B23; 4—B17, B19, B28) were more deteriorated and had been ill for a period longer than recommended for cases for transorbital lobotomy. Further, they occupy a qualitative position somewhat below the average for our group as a whole. It is apparent therefore that if the rate of recovery of these cases should turn out to be lower than that reported by other writers on this technique our results could not be used to confute such a higher rate, determined upon a different class of material. On the other hand should the results we obtained compare favorably with those reported by others, for cases who have not been ill for as long, then our results would clearly have the effect of enhancing the value of data collected on such other material and would serve to allay possibly dangerous haste in resorting to the operation.

We chose to investigate the effects of transorbital lobotomy in chronic cases who are seriously ill for the following reasons: (1) the basic data necessary for evaluating a therapeutic procedure carried out on cases who have not been committed to an institution for at least 2 years were not available, (2) we were primarily interested in those individuals who are already in institutions, and (3) for the collection of most of our basic data (the effect of transorbital lobotomy on olfaction, for example) institutionalization for a period of 3 years or even longer, while a complicating factor, is not an invalidating obstacle.

THERMOCOAGULATION. From our first project we know that the pathological effects of a cortical ablation are not restricted to the cortex ablated (Mettler, '49a). The only tried and tested method for localized destruction of the cerebral cortex is thermocoagulation. Other methods, such as devices for generating other forms of radiant or mechanical energy, chemical coagulants, or dehydration naturally suggest themselves but they do not work well experimentally and, in venturing into new territory, it is best to proceed with caution. Since thermocoagulation has never been attempted over such wide areas of cortex as exist in the human frontal lobe, it was felt that in trial work it might be wise to neglect the cortex in the depths of the sulci and confine thermocoagulation to the relatively small amount of cortex exposed on the summits of the gyri. The task of adapting the Dusser de Barenne instrument and technique to the human brain was consequently assigned to the surgical discipline and Dr. Garcia's modification is described in Chapter 3. Two cases (nos. B15, B16) were selected for thermocoagulation.

VENOUS LIGATION. The problems raised by the recovery of case 38 in our original series of studies after ligation of the superior cerebral veins were critical ones. As pointed out above, various cases have been reported who have recovered following an abortive attempt at lobotomy, which for one reason or another was not carried out or only incompletely so. That all the cortex rostral to the agranular area need be disconnected to eventuate in an appreciable number of hospital releases we have now demonstrated to be unnecessary but since case 38 was one from whom no cortex at all had been removed the question arose as to whether cortical ablation was really necessary and indeed if a simple craniotomy might not be successful, or even the factor responsible for success. Superior sagittal thrombosis is a serious accident in the human but, in neurosurgery, ligature and division of cerebral veins is often done without unhappy results and one operative approach to the problem of convulsive seizures (Scarff, '47) involves division of these vessels. In the simian, venolysis need not produce any very obvious pathology. In topectomy it is usually necessary to divide a certain number of superior cerebral veins and case

Footnote for Table 3—(Continued)
improvement to leave the hospital under these conditions.

Briefly, the ratings may be summarized as follows:

I. *Excellent*

II. Good

III. Fair

IV. Questionable from standpoint of physical accommodation and family's ability to carry through intentions to give support and supervision.

V. Questionable from the standpoint of the family supervision and support for the patient.

VI. Questionable as to whether or not there are any assets in the home situation for the patient.

VII. Situation for patient's leaving the hospital must be developed by social worker.

In the third place we need to have a clear definition of improvement which can also be applied reliably (do we want to know whether the condition is cured or only brought to a remission or merely alleviated and, if one of the latter, for how long a period of time and in what manner?).

Fourthly the rate of spontaneous or unspecific improvement must be determined and finally the rate of improvement after the use of the therapy to be evaluated must not only be established but also must be significantly above the spontaneous or incidental rate.

If the indications for a therapeutic procedure are drawn up in such a way as to include an appreciable number of cases in which spontaneous improvement may occur, the influence which such weighting exerts must be clearly determined before one can proceed any further. In connection with present problems it is well known that regardless of therapy, the incidence of dismissals from psychiatric institutions decreases with duration of commitment. Between one and 2 years it falls sharply. In studying institutionalized cases one is obviously dealing with a fragment of a curve which indicates that the sooner a therapeutic procedure is instituted after the onset of a psychiatric illness the greater the opportunity for error in attributing recovery to the therapeutic procedure employed. One very potent argument for restricting our study of the effects of transorbital lobotomy to cases who were committed for at least 3 years is our knowledge that after 2 years the possibility of spontaneous durable improvement is considerably reduced. It is, of course, possible to organize complexity to a point at which an impasse is reached. It would obviously be a waste of time to attempt to cure ancient cases of advanced neurosyphilis that were in the last stages of mortification and one must be careful not to go beyond an objective statement of the facts. At the time the present project was designed, one could only say that recoveries might be encountered after the use of transorbital lobotomy at a stage of illness in which spontaneous recovery is known to occur frequently but the exact incidence of which was still unknown. These 2 circumstances might or might not be related. Durable recovery after transorbital lobotomy employed at a time when the rate of spontaneous recovery is low, was rare. There was a real possibility that some of the recoveries after transorbital lobotomy were not causally related to the procedure.

In organizing a complex problem the ultimate is reached when such organization is placed upon a personal basis and each case is particularized. Another interesting consideration is the length of time elapsing between the onset of a disorder and the establishment of a durable diagnosis. In psychiatry, as in other fields of medicine, it is obvious that more mistakes are made and more cases go undiagnosed in the early stages of a disease than later. If one does not know what the percentage of spontaneous recovery is there are only 2 safeguards which one can employ to avoid this factor of error—methods designed for problems of disorganized complexity or a retreat to a position in

We need explain more fully only the first consideration but it is an important one.

One way to validate a therapeutic procedure would be to apply it widely with little or no attempt to control variables other than those introduced by the therapy. If the number of cases chosen is sufficiently large, and the variables themselves numerous, the problem is of the type which Weaver ('48) calls disorganized complexity and requires statistical analysis for resolution. Specifically, one has to know what the spontaneous rate of recovery is among comparable groups of individuals who have received (a) no therapy, (b) other types of therapy, and (c) the variety of therapy under investigation. For such an analysis to be meaningful the groups compared must be large as well as quite comparable. If after such figures were compiled there should prove to be a clear-cut advantage in favor of a particular therapeutic procedure then and only then (as a result of such an investigation) could it be said to have any value.

Since it is eminently impracticable to test most therapeusis by such a method we must seek another approach to the problem of evaluation. If, instead of using techniques designed to attack problems of disorganized complexity, one deliberately sets out to organize complexity, the manner in which the organization is done can be used to disclose the influence of one variable factor (such as a therapeutic approach) operating in the presence of several other variables. The method of dealing with problems of organized complexity is obviously fraught with more difficulties than that used for problems of disorganized complexity and involves something more than mere manipulation. Above all the manipulation must be confined to the method of organizing the problems and should not extend to unconscious manipulation of the data gathered. Whenever a physican attempts to define the indications for a therapeutic procedure he begins to organize the complexity of his problem and long before he ever reaches the territory of factor analyses he is faced with definite difficulties which are often unrecognized. Some of these, as they enter into the question of evaluating procedures such as transorbital lobotomy, shock therapy, and psychoanalysis, can be illustrated.

The first necessity in evaluating a therapeutic procedure is a rigid definition of the condition for which it is to be employed. Such a definition may be couched in the form of a statement of a diagnostic category (manic-depressive psychosis, schizophrenia, etc.) or in terms of a psychotic state (painful affect) but it should take into consideration all pertinent objective qualifications of definition and temporal configuration (neurosyphilis as demonstrated by abnormal neurologic findings and a positive spinal fluid and of less than 5 years duration, let us say).

The second necessity is an evaluation of the degree of accuracy with which the previously formulated definition can be reached. Obviously the mere formulation of a definition is useless unless that definition can be effectively applied to the cases to be studied.

Neurology advised against reoperation for the fit pattern, since this was controllable by medication, unless thorough electrical studies were made at the time of reoperation. Indications on the basis of the psychiatric condition were withheld, of course, since this was the province of the psychiatric discipline.

Psychiatry made no recommendation concerning the convulsive pattern but advised that radical lobotomy should be done. The patient's present condition was described as complicated by signs of organic damage which anything less than radical lobotomy might be expected to aggravate rather than improve.

Surgery advised ablation of the remainder of the cortex of areas 9-10. The reasoning involved included not only psychiatric prognosis but also the hypothesis that the integrity of cortex in this region is necessary for the development of convulsive seizures. Radical lobotomy was refused by surgery until the effects of a second topectomy could be observed.

In this situation it was reasoned that if the recommendation of surgery was followed it would provide a valid test of both the psychiatric prognosis and the rather arresting theory concerning convulsive seizures advanced by surgery and that, if the ablation proved to be a failure, the radical lobotomy recommended by psychiatry might still be carried out. From the point of view of the project this case offers an interesting example of the effects of enlargement of the ablation of granular cortex.

SUMMARY

The present project deals with the preoperative and postoperative course of patients treated as follows:

Venous ligation—12 cases:

Rating	Schiz. Heb.	Schiz. Cat.	Schiz. Par.
1 (best)		B12	B5
2	B7, B9	B2, B11	B10A
3	B1, B3	B6	B8
4 (poorest)			B4

Transorbital lobotomy—9 cases (all hebephrenic schizophrenics):

Rating 2—B21, B22A

Rating 3—B18, B20, B23

which spontaneous improvement is known to be minimal. In this instance we have employed the latter technique which, it should be remembered, yields no information at all about what might have happened in a different class of patients.

Transorbital lobotomy was, at the time this work was undertaken, still an unstandardized procedure. Certain aspects of it (for example, the exact importance of the rather special type of shock which is employed in conjunction with it) are still unclear. It would be very easy to miss an essential feature of the technique unless it were performed by a recognized expert. In this situation we invited Professor Walter Freeman to perform the procedure for us and we are happy to say that he kindly consented to do so.

Special Procedures. One case (no. A10, a hebephrenic schizophrenic) studied as a control in our first project was added to the transorbital series. This case, discussed in our previous monograph, was an exceedingly deteriorated one whose condition had shown no change in the 19 months he had been followed by us. He was included to get a *study value from the very bottom of our rating scale.*

In our original series of cases we had performed lateral transcranial lobotomy on 2 cases (nos. A2, A44) who had failed to improve after topectomy. No benefit resulted from reoperation by lobotomy. The converse problem, namely, "Would topectomy have any value in cases in which lobotomy had failed?" sometimes presents itself. The problem is a difficult one. It is hard to see how removing cortex which has already been deprived of its long afferent and efferent connections would produce any change in an individual. About the only way in which one could visualize possible alteration would be to assume that the original lobotomy had been inadequate. This problem again presented itself in the form of a case (MSH) of a young woman who, following lobotomy, had proceeded to terrorize the attendants of Marlboro hospital and who constituted a very real fire hazard. Acting on the assumption that her lobotomy must be essentially incomplete she was transferred to Greystone for an area 9-10 topectomy. Upon reoperation it was evident that the original lobotomy had reached the falx cerebri with dense scarring on both sides and had evidently been about as thorough as most such operations generally are. This case is further discussed in Chapter 15. From a theoretical point of view the case offers an example of the result of cortical ablation of tissue from which the long afferent and efferent systems had previously been severed.

Our original series of cases also included one (case A8) in whom a middle frontal gyrectomy, instead of topectomy, had been performed. This case, listed as a topectomy failure, did not show any improvement in his psychiatric condition (in respect to his interpersonal relations with other patients he grew worse) and developed a definite convulsive pattern. The physician in charge requested reoperation, so we were somewhat at a loss to decide what it would be best to do and consultations of the various disciplines were requested.

Chapter 2

HOSPITAL MANAGEMENT AND SOCIAL EVALUATION

Marcus A. Curry, Archie Crandell, and Violet Bemmels

Why was this research project conducted at Greystone Park rather than in some other institution, perhaps more closely related spatially and in organization to the great university which gives its name to the group responsible for the work? As we previously pointed out (Columbia Greystone Associates, '49) the project stems partially from a series of lectures given by Dr. Fred A. Mettler under the auspices of the New Jersey Neuropsychiatric Association and attended by many members of the staff of the New Jersey State Hospital at Greystone Park, and that hospital was chosen as the site for the first project because it served the area from which most of the patients came whose relatives were interested in having psychosurgery performed at that time.

The mentally ill in New Jersey were cared for to some degree by county hospitals but mostly by the 3 state hospitals located at Marlboro, Trenton, and Greystone Park. The latter, and largest of the 3, is located about 33 miles due west of New York City, near Morristown, and is surrounded by 1200 acres of beautifully rolling northern New Jersey land, some of it in cultivation, some in woodland, and a part, surrounding the buildings, rivaling in beauty the campuses of any of our large eastern universities.

The resident patient population of over 5800 is housed in 8 large buildings. The oldest, the Main Building, was constructed in the 1870's and is modeled on the famous Kirkbride pattern so popular at the time. Its administrative center and 2 large wings, for men and women patients, extends out and back, step-like, on each side. On its 4 floors, each side has a total of 20 wards and presently houses about 2900 patients for continued treatment with some of the back wards housing the more overactive problem cases. This Main Building was soon crowded and in 1901 another large building was constructed of the local gray stone some distance in the rear, to house those patients requiring only a place to eat and sleep. This building, named the Dormitory Building, has now about 1700 senile and sclerotic patients quartered on its 14 huge wards. At the time of the First World War, a modern psychiatric clinic and admission building was constructed on the other side of the Main Building and in the late 1920's the new Reception Building was built farther down the Main Drive to accommodate 125 men and 125 women on its wards where the most thorough and complete

Controls—6 cases:

Rating	Schiz. Heb.	Schiz. Cat.	Schiz. Par.
1		B25	B24
2	B27		B10, B26
3	B22		

Thalamotomy—2 cases (B13, B14, both hebephrenic schizophrenics with a rating of 4).

Thermocoagulation—2 cases (B15 a catatonic and B16 a hebephrenic schizophrenic, both with ratings of 2).

Topectomy after lobotomy—1 case (MSH, hebephrenic schizophrenic).

Enlargement of cortical ablation—1 case (A8, epileptoid pattern).

checked since obviously we could not state that the patients had received all indicated therapy if they had not been treated by this department, or at least considered and treatment withheld for a good reason. While the medical members of the staff were asked to review the cases directly under their supervision, the actual clerical labor of surveying the hospital records was in the hands of Miss Dorothy Logan, who had been trained in the hospital and was familiar with the procedures and records and could thus conduct the survey more rapidly than had an outsider been assigned to this task.

While all the patients who were considered had received the normal admission examination and a history had been obtained in a routine manner by the Social Service Department, it was found that in many cases further information had to be obtained from the families in ruling on debatable questions and that repeated psychiatric evaluation was necessary to confirm or correct the diagnosis which had been made by the resident staff, in many cases several years previously. It was found that this load was too great to be carried by the resident staff of psychiatrists and social workers and the project therefore assigned a social worker and 3 psychiatrists to carry out this necessary screening.

It was of interest in the first research project that improvement of a patient following operation might be so pronounced that the medical staff would pass the patient for parole only to find that there was no suitable environment in which he could be placed. With this in mind, the "satisfactory home to which to return if improved" was one of the criteria and this problem took much of the time of the social worker during the early days of the selection of patients.

Out of the 90 records selected in the first survey of the hospital, 34 patients were screened who seemed to meet in great part the criteria outlined above. The social worker was assigned the task of (1) obtaining permission for surgery from the families of these 34 patients and their promise to accept responsibility for their care following operation if the patients were released from the hospital, and (2) helping the patients who were considered ready for release by the Greystone staff adjust in the community.

The majority of the relatives were seen but once. Nine of these families refused permission for operation mostly because they did not feel that brain surgery had developed far enough to assure a successful result. Several families had read articles concerning psychosurgery and consulted other physicians who had advised them to wait. Others had noted little or no improvement in patients who had received conventional surgery. On the other hand, several families refused surgery, not on the basis of the possibility of failure but on the basis of the possibility of success since these families did not want to be responsible for the after-care of their relatives.

Twenty-five families signed for surgery. Of these 25, there were 20 who expressed a desire to have the patients in their own homes after the operation. Of the 20, it was obvious that there were 2

studies could be made of all newly admitted patients. About 1930 a unit for the tuberculous mentally ill was constructed, with 3 other smaller brick buildings to care for the overflow from the Dormitory Building. The campus picture is completed by the many buildings housing doctors, nurses, and staff and the utilities necessary to operate this largely independent community of almost 7500.

The Clinic Building, midway between the Reception and Main Buildings, is now used for shock therapy, acute medical and surgical cases, and contains the suite of operating rooms used in this project. One ward in this building, on the floor just below the operating rooms and known as 17-A, was set aside for the patients being studied. In the same building also were located the offices of the psychosurgery project and various testing rooms utilized by the psychiatric, neurologic, psychologic, and other disciplines in their studies.

The hospital is under the direct control of the Medical Superintendent and Chief Executive Officer, who is responsible to the Board of Managers of the institution, composed of 7 outstanding non-salaried men and women of the community. They in turn are responsible to the Commissioner of the Department of Institutions and Agencies and he, through the State Board of Control, is responsible to the Governor. Thus, in this project as in the first, the approval of this whole chain of command was necessary, and it is a tribute to the excellent formulation in carrying out that project, that permission was gladly given at all levels. Conferences were held at the hospital by the senior collaborators early in the year and the tentative nature of the work to be performed was outlined. A real problem in case selection presented itself because of the many criteria which had to be met before a patient could be included. Originally, it was hoped that psychoneurotics, involutionals, and manic depressives, as well as schizophrenics, could be selected in separate groups and similar surgery performed. It might be thought that with a patient population of over 5800 to choose from, these 4 groups could be formed easily. However, when it is realized that aside from being in certain definite age groups, it was necessary that patients selected have minimum educational qualifications of grade school graduation, have been ill at least 3 years without remission and received all indicated therapy and have a good home to go to if the operation was a success, we find that the field is narrowed down greatly. When, however, the prohibition against any history of obvious psychosis in the blood line, any organic brain disease, or any other systemic disease is also added, we find that the selection becomes so restricted as to rule out the psychoneurotics entirely and leave only 4 manic-depressive cases. It was necessary, therefore, to drop these classifications from our study.

We began our selection of cases by first surveying the entire hospital population and weeding out those obviously not suited for consideration; this included the aged, the sclerotic, those whose illness had been of short duration, and those with unsatisfactory family histories. The records of the Shock Therapy Department were then

The female patients out-numbered the male patients 2 to one on the ward and necessitated a mixed assignment of personnel, which is rather unique in mental hospital practices. At least one graduate nurse was on duty throughout the 24-hour period, and during the day shift there were 2 graduate nurses and 4 affiliate nurses assigned to the ward. A minimum of one male and one female attendant was on duty with 2 male and 2 female attendants on the day shift.

Accurate noting of patient's condition was carried out both by the use of a Payne-Whitney Behavior Chart and by descriptive noting in detail on the ward journal as well as on the note sheets in each individual record. The patients seemed to enjoy the pressure of activity on the ward where numerous medical and laboratory tests were under way almost continuously, and the patients also made frequent short trips from the ward to other offices for various psychologic and technical tests.

A detailed report of the technique and results of these various tests will be found in the individual chapters which follow, devoted to the various disciplines.

The housing arrangements for the patients included in the project have been described, but arrangements for the care of the professional members of the Columbia-Greystone project merits a word. Only a small percentage of the workers were resident members of the staff of The New Jersey State Hospital at Greystone Park and by far the larger number had been recruited from Columbia University and the departments of the College of Physicians and Surgeons. During the period of the intensive testing, quarters were provided for several of the psychologists in the nursing home and while the operations were in progress, the surgical and medical staff were quartered in doctors' suites in the Main Building. Those members of the project who were not required to live on the hospital grounds were transported daily by hospital car from the George Washington Bridge to the hospital in the mornings and returned there in the evenings. Meals in the doctors' and nurses' dining rooms were provided for both those members in residence and those who visited the hospital daily. Also, since each operation was rather lengthy, it was necessary to provide nourishment and meals for all of the operating room staff when it was convenient for them to eat, since many times the termination of an operation did not coincide with the regular hours for meals in the staff dining rooms.

We have noted above that the patients included in the project were largely those whose families had shown a great interest by frequent visits and it was necessary to control this visiting so that the program of testing and interviewing would not be interfered with during the project. Visiting, which was permitted in the general hospital population on Tuesdays, Saturdays, and the first Sunday of each month, was restricted to Sundays only since on these days testing and interviewing was at a minimum. It also was found necessary to request the relatives not to bring candy and other articles of food as had frequently been their custom, since this interfered with the control dietary intake which was followed in the project.

(B11, B21) who would want the patient only if she were sufficiently improved to live peaceably with the family. Of the 5 who signed for surgery but could not take the patient home, 2 (B3 and B10A) were willing to pay for the patient in a boarding home. The other 3 came from such complicated family situations that it would have taken much manipulation to work out a suitable environment for the patient.

The question has sometimes been raised as to whether attempts had been made to coerce or persuade the relatives to sign the permit. The method used was to give only the information available to social service; that is, that a small percentage of operated patients improve a great deal, most operated patients feel better and improve in varying degrees, and that a few fail to show any improvement. The hopeful and enthusiastic attitude on the part of the interviewer may have been transferred to the families in spite of efforts not to verbalize it, but it was the interviewer's opinion that the underlying cause for the signing of the permit was the very real fear on the part of the relatives that the patient would remain in the hospital for his lifetime if something drastic were not attempted. It would appear then that no great difficulty was encountered in getting the relatives to sign permits and assume responsibility for postoperative care since no attempt was made to persuade those who were reluctant. Twenty-five out of 34 relatives signed willingly and with as much information as was available to social service.

The evaluation of the families at the time of the operation was not highly accurate for several reasons. As stated above, most of the families were seen but once before the operation. Again the attitude of the families changed during the time the patients were being operated. Some relatives grew in tolerance, patience, and understanding. Others were able for the first time to express their feelings of rejection for the patient. One of the criteria used in selecting patients for inclusion in the project was the fact that they had interested relatives, and the fact that the relatives had visited the patient consistently over a period of years was the chief criterion of their interest. Postoperative experience showed that consistent visiting was not always an indication of interest but sometimes a fear of criticism by relatives-in-law or an expiation of guilt for rejection of the patient.

The interviewing of relatives, obtaining further family and personal history, and the preliminary psychiatric restudy had been carried on while the patients remained on their original wards in the various buildings, but on 8/23/48, 29 patients were transferred to the special research ward in the Clinic Building, known as 17-A. Most of these patients came from the men's and women's services in the Main Building but several had resided on the Dormitory wards. About 2 weeks later an additional patient was transferred from the Female Service of the Main Building, and the total of 33 was reached somewhat later with the inclusion of a male patient for reoperation from the first series, of a first series patient added for transorbital lobotomy, and of a female patient transferred October 18th to the ward from the New Jersey State Hospital at Marlboro.

Following lunch, reports were made on anatomy, physiology, vestibular and autokinetic movements, olfaction, medicine, neurology, and pathology. The presentation of the pathological report was quite detailed and lengthy and, after the report on psychiatry, the meeting concluded with a short psychiatric evaluation by the Greystone staff and a general discussion. In all, 58 of those associated with or interested in the project were present at the meeting in the nurses' classroom and at the luncheon and supper in the nurses' dining room.

At this meeting it appeared that the psychiatric discipline considered none of the patients to be recovered, much improved, or improved, but that 6 were slightly improved and 18 unimproved. One patient, the one who had been transferred from the Marlboro State Hospital for surgery, was considered to be worse following the operative procedure. Four patients were felt to be parolable. In comparing this evaluation with the findings at the hospital staff meeting, there was complete agreement on 2 patients (B7 and B10A), and it was agreed that A10 was improved and could be paroled. However, B25, a control who had not been favorably considered by the hospital staff, was felt by the psychiatric discipline to be not only slightly improved but also parolable. Psychiatry did not see the improvement in B1 and B3 that the hospital staff had noted. It was decided, therefore, that patients who were considered to have shown some improvement by either the staff or the psychiatric discipline should be referred to the Social Service Department to see what could be done toward their return to the community and 8 cases were so recommended.

Shortly after this meeting it was decided that the separate ward for the research patients would no longer be necessary and accordingly on February 1, 1949, 16 women and 10 men were transferred to the Dormitory Building and 2 women patients (B7 and B10A) were transferred to the Female Surgical Ward in the Clinic Building, and at 4:00 o'clock that afternoon the research ward was officially closed.

On August 17, 1949, 4 of the 8 (B1, B7, B10A, and B25) were out of the hospital. Two of the patients (B3 and A10), at first considered improved, had regressed sufficiently in a few weeks for the hospital staff to feel that they should not leave the institution. The other 2 (B5 and B8) had relatives who expressed their rejection of the patients after the operations and refused to take them home. They stated that they felt the patients had not improved sufficiently and revealed great fear of the patients' hostility and dominating attitudes. These relatives might have been persuaded to remove the patients but only at the risk of subjecting the patients to further frustration, unhappiness, and quick return to the hospital.

Of the 4 patients on parole, one (B25) had not been operated. He could not return to live with relatives and a supportive environment was found for him which seemed to suit his wishes and his needs. He is making an adjustment which is satisfying both to himself and to his employer, a chicken farmer who is training the patient to perform this type of work.

The first patient to be operated upon in the project went to the operating room at 7:30 a.m. October 4th and was returned to the ward at 1:55 p.m. The second patient was taken to the operating room at 3:30 p.m. and returned to the ward at 8:00 p.m. It will thus be seen that operating even 2 patients a day was a very formidable task for both the surgeons and the other members of the operating room staff and this rate could not be maintained throughout the project. The last operations were a thermocoagulation on October 18th, a topectomy on the 19th, and a reoperation, topectomy, on a Project I patient on the 20th. However, on the 28th, 9 patients on the project were taken to the operating room where Doctor Freeman performed bilateral transorbital lobotomy on each patient, details of which will be found in the chapter on Surgical Procedures.

During both the period before and after the operations, active participation by the Occupational Therapy Department permitted the carrying on of regular ward classes and considerable individual work. The Recreation Department also assisted in maintaining activities, including a large Halloween party and other affairs during the holiday season. Movies were shown on the ward at intervals. Bingo games served to sustain the interest of the patients and most of them were outdoors whenever the weather permitted.

Retesting of the patients by the various disciplines took up the next several weeks and on January 5th all the patients appeared before a regular meeting of the hospital staff to determine their opinion as to the improvement or lack of it in each case and as to the advisability for parole of each patient. In each case a short summary was read of the patient's preoperative condition and of a postoperative examination by a member of the hospital staff. The patient was then brought into the staff room and questioned by the staff members, particularly by the physician on whose Service the patient had been prior to selection for inclusion in the project. As a result of this staff meeting, the patient was placed in one of 3 categories: (1) parolable, (2) improved but not sufficiently for parole, and (3) unimproved. Of the 12 patients who had venous ligations, 4 were considered parolable (B5, B7, B8, and B10A); 2 were considered improved (B1 and B3). The 2 patients who received thalamotomy were considered unimproved, as were the 2 who had received thermocoagulation. Eight of the 9 patients who had received transorbital lobotomy were considered unimproved but A10 was considered to be improved. All of the 6 control cases were considered to be unimproved.

Immediately following the conclusion of the operating period, a meeting was scheduled for a tentative report on this, the second Columbia-Greystone project, and this was held as scheduled January 14th at The New Jersey State Hospital at Greystone Park. Following a report on the present status of the patients in the first Columbia-Greystone project, the morning session was devoted to a report on the nature of the present project, a description of hospital management, a social evaluation summary, and a report by the surgical discipline.

Chapter 3

SURGICAL PROCEDURES

J. Lawrence Pool, Francisco Garcia, Will N. Spear, and Paul Teng

Eighteen patients were operated upon as follows: in 12 cases bilateral ligation of the superior cerebral veins was carried out as described below; in 2 cases bilateral surgical thalamotomy was performed, an incision being made into the region of the dorso-median nucleus on each side; in 2 cases thermocoagulation of the cerebral cortex in the rostral portion of each frontal lobe was done; while in the 2 remaining cases topectomy procedure was carried out. In one of the latter a prefrontal lobotomy had previously been done, and in the second case a previous cortical ablation. The reasons for doing these various procedures have been presented in Chapter 1.

All of these operations were done under thiopental sodium anesthesia supplemented by nitrous-oxide-oxygen administered through an intratracheal tube. Transfusion, saline or glucose solution were given during operation as required. In all cases save the 2 on whom thalamotomy was done, a coronal incision was used so that the scalp could be reflected anteriorly. A single, generous bifrontal bone flap was then turned spanning the superior longitudinal sinus, and hinged by the right temporal muscle. The precise site and extent of the bone flap depended on the exposure desired in each case. Generally the posterior limb of the flap was placed 1-3 cm caudal to the coronal suture. Each flap measured 9-11 cm in the antero-posterior plane, and extended 4-5 cm to each side of the midline.

In making large scalp incisions such as those of the coronal type used for topectomy, the time of opening and closing the scalp in 5 cases (B2, B3, B4, B5, and B7—see fig. 9) was materially shortened and the loss of blood reduced to a minimum by the use of zippers instead of hemostatic clamps or Michel clips, a technique developed by one of us (J.L.P.).

In 9 additional cases transorbital lobotomy was performed by Dr. Walter Freeman; a brief description of the technique is given on page 54.

Ordinary zippers were used about 6 inches in length. After sterilization by boiling or autoclaving, they were sutured to the scalp so that the metal track or slide covered the line of the proposed incision (See Plate I Top).

To make the incision, each zipper is simply opened and the scalp incised as usual. Since each suture that anchors the zipper also serves

Two patients are at home with relatives but are not well enough to be employed. One of these patients (B1) has responded to a change in the attitude on the part of her mother who had grown in tolerance and understanding during the operative procedure. She is now showing the patient affection and attention and the patient is showing marked improvement. From being negativistic, defiant, and almost mute, she has become friendly and helpful to her family. The other patient (B7) is getting attention and affection from her maternal aunts and has become slightly more friendly and communicative but at times has violent outbursts against her mother and sisters when it is obvious that she still suffers from hallucinations and delusions. The fourth patient (B10A) who had shown the greatest improvement of the operated patients, lived in a boarding home with the expectation that her husband would re-establish their home. After several months the husband began to express his resistance to living with her because of her dominating attitude and finally threatened a legal separation. Social service had attempted to interest the patient in employment which would be suitable as far as her needs and capabilities were concerned, but she had expressed a great abhorrence of working. When her husband threatened separation, however, she obtained a job as a children's nurse, probably as a gesture of defiance. No attempt was made to persuade the husband to re-establish a home since his rejecting attitude might only cause further frustration and breakdown. Further intensive work with this patient on the part of social service appears indicated to prevent another regression.

SUMMARY

The management of a cooperative research project as conducted by a great university working with and within a large public mental hospital has been described. Three operated patients and one control were returned to the community. Social service experience with the religious and welfare organizations, as well as with the immediate families of the patients in this project, indicates that additional and different after-care is needed. Families become emotional and positive in their feelings for the patient at the time of signing permission for operation, but over a period of months their old negative feelings return unless they, themselves, have undergone a change of heart. In spite of alteration of the patient as a possible result of surgery, these negative feelings may again cause the patient to regress. Since few if any religious or social welfare organizations have a definite program for social service in mental cases or staffs equipped to deal with such patients the evaluation of psychiatric therapeutic efforts requires the assignment of special personnel to carry on the work of determining what influence the home situation is exerting on the patient's behavior.

making the incision, and closing the wound is only 15 to 18 minutes as compared with double or triple this time by conventional methods in this type of operation. At the end of a long operation, moreover, it is particularly gratifying to close the wound simply by inserting no more than 3 or 4 approximating sutures and then zipping the scalp edges together.

In summary, this is a time-saving and blood-saving technique of opening and closing large coronal scalp incisions which makes use of ordinary zippers sutured to the scalp before making the incision. Wound healing is satisfactory provided the technique is carried out as described.

VENOUS LIGATION

In each case a dural flap was opened in "C" shape fashion on each side and reflected medially. Photographs were taken of the exposed brain on the right side only before and after venous ligation.

The appearance of the bone, dura, pia arachnoid, vessels, and cerebral cortex was recorded before ligation of the veins. No definite pathological changes were found on gross examination at the time of the operation.

Ligation of the superior cerebral (cortico-dural) veins was performed both with silver clips and the electro-cautery on both sides in all these cases.

Physiologic saline solution at approximately 37° C. was used liberally for irrigation of the cortex on both sides in all these cases.

Penicillin solution (1000 units per cc) was instilled intradurally in 6 of the cases (B1, B2, B3, B4, B5, and B7) and extradurally only in the other 6 cases (B6, B8, B9, B10, B11, and B12).

The dural flaps were closed in water-tight fashion in all cases except B5 where they were left open, and in case B8 where a small opening anteriorly was not closed. In both these cases the dural defects were covered with a layer of oxidized cotton.

In all cases after replacing the bone flaps, the frontal burr holes were covered with tantalum discs and the wounds closed with layers of interrupted black silk sutures in 7 cases and with zippers in 5 cases (B2, B3, B4, B5, and B7). (See fig. 9.)

EXTENT OF VENOUS LIGATION. The coronal suture at the midline was chosen as a point of reference. Attempts to outline areas of the cortex according to Brodmann's map (Mettler, '48a) was based exclusively on gross anatomical landmarks, no electrical stimulation being done in any of these cases.

In 5 cases (B1, B2, B3, B4, and B5) all the superior cerebral veins were ligated bilaterally from the tip of the frontal pole to a point 5 cm caudal to the coronal suture.

In 7 cases (B6, B7, B8, B9, B10, B11, and B12) no cortico-dural

VENOUS LIGATION

		DETAILS of OPERATIVE TECHNIQUE			After VENOUS LIGATION	
PATIENT NUMBER	SURGEON	EXT. OF BONE FLAP	MISCEL-LANEOUS	EXT OF VENOUS LIGATION	INCREASED Intra-Cranial PRESSURE	NEUROL FINDINGS
B1 41244	L POOL	CS {A-4 P-35	PI		O	N S
B2 38574	L POOL	CS {A-6 P-4	R PI Z		Marked at operation	N S Conv
B3 35775	L POOL	CS {A-6 P-3	PI Z	5cm Caudal to CS	O	Conv
B4 38661	L POOL	CS {A-4 P-45	R PI Z		Marked at autopsy	N S Conv
B5 46658	L POOL	CS {A-7 P-35	PI Z		Marked at operation	
B6 33500	F GARCIA	CS {A-6 P-4	R PE		O	
B7 44646	L POOL	CS {A-8.7 P-0.3	R PI Z		O	Conv
B8 32184	F GARCIA	CS {A-7 P-3	R PE		O	
B9 43164	F GARCIA	CS {A-8 P-3	R # PE	2 cm Caudal to CS	O	
B10A 44961	F GARCIA	CS {A-7 P-3	R PE		O	
B11 44403	F GARCIA	CS {A-8 P-35	PE		O	
B12 45806	F GARCIA	CS {A-75 P-25	PE		O	Conv

A – ANTERIOR TO CS
Conv – CONVULSIONS
CS – CORONAL SUTURE
N S – NEUROLOGICAL SIGNS
P – POSTERIOR TO CS
PE – PENICILLIN (1000 units a c.c.) EXTRADURALLY
PI – PENICILLIN (1000 units a c.c.) INTRADURALLY
R – CORTEX BECAME REDDER FOLLOWING VENOUS LIGATION
Z – ZIPPER CLOSURE
– DURA LEFT OPEN BILATERALLY

FIG. 9. Surgical data on cases in whom the frontal superior cerebral veins had been ligated

as a hemostatic device, the assistant need not compress the edges of the wound. The degree of hemostasis is not sufficient to result in any grossly observable ischemic tissue necrosis. Indeed, a few of the larger vessels may bleed and require cauterization or the temporary application of a Michel clip.

In the 7 cases (2 of which were not patients in this series) on which this technique has been used, *healing was entirely satisfactory in all* but 2. In one of these 2 cases there was a slight overlap of the wound margins near each end of the wound of about 1.5 mm.

In another case where 2 anchoring sutures overlapped each other, some local ischemia occurred. In none of these 7 cases, each of whom had a large coronal type of flap, was there any evidence of a collection of subgaleal fluid or blood postoperatively.

With this technique the total time required for applying the 2 zippers,

to the coronal suture, and a second group (B6-B12 inclusive) where venous occlusion extended only 2 cm caudal to the coronal suture. It is clear that the first of these 2 groups suffered more drastic postoperative changes than the second group with less extensive venous ligation.

Of the first group one case (B1) was stuporous for 2 days with paresis of the right upper extremity and aphasia for 10 days. Another patient, B2 remained in a fluctuating comatose state for 5 days, and was aphasic for 14 days, with paresis of the right lower extremity, Babinski sign on the right side and paralysis of the right upper extremity for about 16 days. During that period the patient also had paresis of the left upper extremity lasting for only 24 hours.

Case B3 suffered several generalized convulsions postoperatively. (See Chapter 5.)

Case B4 never regained consciousness, examination demonstrating abnormal neurologic changes bilaterally (rigidity, paresis, hyperreflexia, and a bilateral Babinski sign). Twenty-four hours after operation she suffered a convulsion beginning in the left upper extremity. Fifteen minutes after this first seizure a generalized convulsion occurred, beginning in the right upper extremity. Twenty-six hours after operation the pupils were dilated and fixed and bilateral Hoffmann and Babinski signs were noted. Removal of approximately 20 cc of bloody fluid from beneath the scalp flap did not alter her condition, and the patient died 30 hours after venous ligation.[1]

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1. Gross appearance of brain of case B4. The cerebral hemispheres are slightly asymmetrical due to widening of the posterior half of the left frontal lobe. The medial surface of the lobe in this region bulges toward the midline. The gyri over the convexity of each frontal lobe and to a lesser degree over the remainder of the cerebral surfaces are flattened and the sulci correspondingly narrowed, and this is more marked in the posterior half of the convexity of the left frontal lobe. Here the gyri are broader than normal and show focal areas of dusty discoloration where petechiae have apparently coalesced. In this area there is less resistance to palpation. These zones include the posterior extremity of the left superior frontal gyrus, the posterior extremity of the left middle frontal gyrus, the upper third of the left precentral gyrus, the posterior extremity of the left superior frontal gyrus, and the upper extremity of the left precentral gyrus. In these areas there is recent hemorrhage into the sulci and these are located over the posterior halves of the left superior middle and inferior frontal gyri and over the left precentral gyrus. On the right, such hemorrhage is present to a lesser degree and is localized over the posterior extremity of the right inferior frontal gyrus and the lower extremity of the central gyri. The remainder of the surfaces of the cerebrum show no unusual features. The cerebellum and brain stem are externally negative. The remainder of the leptomeninges is normal. The arteries at the base of the brain show no unusual features. There are deep tentorial grooves on the inferior surfaces of the unci, that on the left being roughly 3-4 mm from the medial margins of these gyri. The superior cerebral veins in the frontal regions are not distended. On the right side an anterior anastomotic vein connects the central veins with those in the anterior fossa. On the left side no anterior anastomotic vessel can be seen. The superior sagittal sinus is patent throughout its course. On separation of the cerebellum and brain stem from the cerebrum, the posterior portion of the left hippocampal gyrus is found to have herniated through the incisura of the tentorium for a distance of roughly 3-5 mm. The dorsal surface of the cerebellum shows evidence of moderate compression.

veins were occluded more than 2 cm caudal to the coronal suture. In patients B11 and B12 a large cortico-dural venous channel (not ligated) was found 3 cm posterior to the coronal suture, formed by the union of 2 large veins, of which the posterior one (not ligated) appeared to drain the areas adjacent to the central fissure, while the anterior one which was ligated ran along the rostral border of what appeared to be area 6 of Brodmann. In these 7 patients venous ligation extended rostrally to the frontal poles as in the first 5 cases.

In case B1 the superior longitudinal sinus had to be ligated 2 cm caudal to, and again 4 cm rostral to the coronal suture, which was the only effective way of controlling bleeding from torn veins flowing into the sinus between these 2 points. This patient showed signs of surgical shock during the operation but this was successfully treated with blood transfusions.

OBSERVATIONS FOLLOWING VENOUS LIGATION. In all these cases the blood in the ligated veins distal to the point of occlusion became darker. This observation is confirmed by color photographs taken before and after venous ligation.

Five to 10 minutes after ligation of the majority of the superior cerebral veins, the column of blood in those vessels became quite clear for 2 to 10 mm distal to the point of occlusion, and for 20 minutes or longer palpation of the veins suggested that the blood distal to the point of occlusion remained unclotted, although no vessel was punctured to verify this impression.

Five to 10 minutes after venous ligation was completed on each side the surface color of the exposed brain seemed to be more red as if from hyperemia or venous stasis.

Marked brain edema occurred in 2 cases (B2 and B5) while the brain was exposed. In case B5 a slight degree of cerebral swelling that was noted bilaterally prior to venous occlusion became more pronounced after bilateral venous ligation. In this case there had been some difficulty with the respiratory exchange due to temporary angulation of the intratracheal tube. The effects of caffeine and sodium benzoate (grains 15 intravenously), hypertonic 50 cc solution of glucose intravenously and finally elevation of the head were tested separately in this case, and it was observed that each clearly reduced the degree of cerebral edema, although never enough to permit closure of the dura. In case B2, although cerebral edema occurred after venous ligation was completed on both sides, it was not as severe as in case B5, and dural closure was carried out bilaterally despite some tension.

Postoperative Course

In correlating the extent of venous ligation and the postoperative course, these patients fall into 2 groups (fig. 9). A first group (B1-B5 inclusive) in which venous ligation extended as much as 5 cm caudal

to the coronal suture, and a second group (B6-B12 inclusive) where venous occlusion extended only 2 cm caudal to the coronal suture. It is clear that the first of these 2 groups suffered more drastic postoperative changes than the second group with less extensive venous ligation.

Of the first group one case (B1) was stuporous for 2 days with paresis of the right upper extremity and aphasia for 10 days. Another patient, B2 remained in a fluctuating comatose state for 5 days, and was aphasic for 14 days, with paresis of the right lower extremity, Babinski sign on the right side and paralysis of the right upper extremity for about 16 days. During that period the patient also had paresis of the left upper extremity lasting for only 24 hours.

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Case B5 had an uneventful postoperative course in spite of the fact that she had an extensive venous ligation and marked edema of the brain at operation, preventing closure of the dura on both sides.

The second group of these cases ran a relatively smooth postoperative course, except for 2 cases who had a few generalized convulsions (see Chapter 5). All these patients were up and about by their fourth postoperative day.

Comments on Ligation of the Cortico-Dural Veins of the Frontal Regions

1. Ligation of the superior cerebral veins, when extensive, is a dangerous procedure. The number and size of the ligated veins and the adequacy of the compensatory mechanisms to take care of the surgically imposed alterations in the cerebral circulation seemed to be the major factors in determining the degree of venous stasis, edema, and hemorrhagic encephalomalacia produced by venolysis of this kind.

2. Such pathological changes are greatly increased when the Rolandic complex of veins are involved, because of the greater magnitude of disturbances in hemodynamics, the greater extent of cerebral tissue involved, and the functional significance of the neural structures affected (Merwarth, '42).

3. Two points of neurosurgical importance may be emphasized. First, the greater the extent of superior cerebral venous ligation, the more profound are postoperative neurologic sequelae apt to be. Second, if the dura is left open in the presence of cerebral edema secondary to venous ligation, the risk of these complications is minimized.

4. Venous ligation is a very crude method of interfering with the function of cerebral cortex.

Section of the cerebrum reveals a series of circumscribed recent hemorrhages in the parasagittal areas of the frontal and parietal lobes. These are more pronounced on the left than on the right side. They are present in the posterior one third to one half of the left superior and middle frontal gyri being located chiefly in the subcortical white matter but extending into the overlying cortex as well. They are present also in the dorsal portion of the left central gyrus, and here also they involve chiefly the subcortical white matter. The largest of these hemorrhages measures roughly 2 x 1 1/2 cm in cross section. The hemorrhages on the right are smaller, the largest measuring roughly 3/4 x 1/4 cm in cross section. They are present in the central white matter of the posterior portion of the right superior frontal gyrus. All of the effected gyri are swollen and there is obscuration of the line of demarcation between gray and white matter. The cortex of the posterior third of the left superior frontal gyrus is studded by petechiae and there is similar involvement of the posterior fourth of the right superior frontal gyrus. Where they are most numerous, these petechiae are coalescent. There is lesser involvement of the cortex of the dorsal extremity of the right central gyri. The hemorrhage described into the leptomeninges over the posterior portion of the left frontal lobe penetrates into the superior and inferior frontal sulci to a varying degree. The genu and anterior portion of the body of the corpus callosum are slightly rotated in a counterclockwise direction and compressed. The frontal horns of the lateral ventricles are reduced in size due to this compression. The left basal ganglia are displaced slightly in a ventral direction.

Section of the cerebellum and brain stem reveals no abnormalities of those structures.

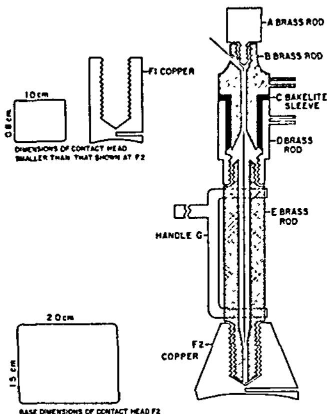


FIG. 10. Diagram of modified Dusser de Barenne's thermode.

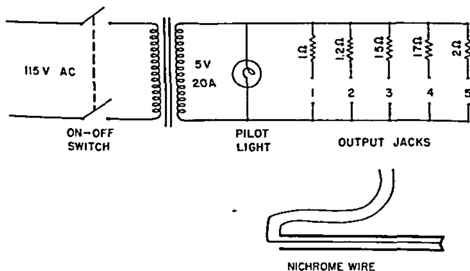


FIG. 11. Power supply of thermocoagulating unit.

THERMOCOAGULATION OF CEREBRAL CORTEX

In 1933 Dusser de Barenne ('33) described for the first time a technique for laminar destruction of nerve cells of the cerebral cortex. He found that by applying the heated surface of a thermode to the brain at a given temperature for a definite length of time a precise number of layers could be destroyed without disturbing the remaining cortex. With this method, the application of 65° C. for 2 seconds would destroy the 2 outer layers of the cerebral cortex of a monkey, while if 70° C. were applied for 3 seconds only the 3 outer layers were destroyed. (Dusser de Barenne and Zimmerman, '35.) Thermocoagulation "allows one to destroy, at will, any number of cortical layers and has the following additional advantages: (1) the continuity of the cortex is undisturbed, (2) no bleeding occurs, (3) the killed region is strictly confined to the heated area, (4) the cortex immediately outside the killed area is functionally normal, and (5) scar formation and retraction are absent in the adjacent cortex." (Dusser de Barenne, '37.)

While part of these observations have been verified by us (Francisco Garcia with Irving M. Greenberg) in experimental work with cats, as far as we know this technique has never before been tried on the human brain. It was thought, however, that this manner of destroying brain tissue could be used in clinical neurosurgery to supplant cortical ablations such as in topectomies, in operations on the cerebral cortex for the treatment of abnormal involuntary movements, etc. Thus if a selected portion of the brain could be destroyed without disturbing surrounding regions, such surgical procedures could be expedited with perhaps a lower incidence of convulsive disorders.

Accordingly part of the cortex judged to be Brodmann's areas 9 and 10 was coagulated bilaterally in 2 of our patients (cases B15 and B16).

Method

A modification of Dusser de Barenne's instrument (Dusser de Barenne, '37) was used which was an electrically heated thermode (fig. 10). The current was regulated by means of transformer and resistors (fig. 11) and different temperatures were obtained according to the current passed through the Nichrome wire heating element. The temperature in the thermode was recorded with a thermocouple device. The thermocouple was made of a copper-constantan joint inserted into a small hole of the thermode (fig. 10 and Plate I Bottom). The e.m.f. was measured with a millivoltmeter and no second joint at a constant temperature was included since accurate measurements were not necessary. The thermode with its handle as well as the copper-constantan wires were sterilized by soaking in 70 per cent alcohol for 1 hour. With this instrument 100° C. applied for 10 seconds to the cortex of the cat's brain destroyed all the gray matter of the presenting



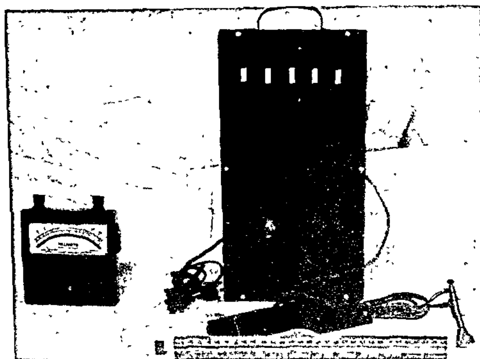


Plate I A. (Top) Zipper technique for opening and closing coronal scalp incisions: A. Application of zippers. Left zipper has been sutured in place. Right zipper ready for suturing. B. Zippers have been opened and scalp incision completed. C. Wound ready for closure by fastening up zippers. D. Scalp incision inspected by opening zipper 24 hours after operation.

Plate I B. (Bottom) Complete unit for thermocoagulation of cerebral cortex.

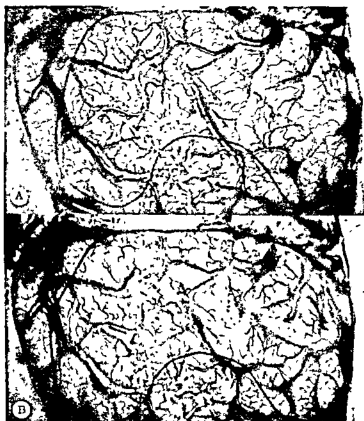




Plate II A (Top) Black silk thread outlines area of cortex to be coagulated B. Appearance of cortex following thermocoagulation.

Plate II B. (Bottom) Postoperative pneumoencephalograms. C. Lateral view (B14) the centrally placed silver clips mark the site of the thalamic incisions D In AP view (case B13) the centrally placed silver clips mark the site of the thalamic incisions.

surface of the coagulated gyri but did not affect the gray matter in the depths of the sulci.

In patients B15 and B16 the brain was exposed through a craniotomy similar to that for the venous ligation cases described above. In these 2 patients while the opening in the bone did not extend more than 1.5 cm caudal to the coronal suture, it was carried forward as far as the extent of the frontal air sinuses permitted. In B15 the dural opening extended 5 cm to the right of the midline and 3.5 cm to the left of the midline; and in B16, 6 cm to either side of the midline. In the antero-posterior plane at the midline the dural opening measured 8 cm in both cases. Part of Brodmann's areas 9 and 10 were outlined with a black silk thread (Plate II A) and thermocoagulated bilaterally by successive applications of the thermode on the convex or lateral aspect of the prefrontal cortex only.

On each 10 second application the initial temperature of the thermode was 100° C. On one occasion the thermode became adherent to the surface of the brain of the most rostral and medial portion of the cortex on the left side (case B15), so that the time of application was prolonged to 25 seconds. In case B15 the surface of thermocoagulated cortex was roughly determined as 18 square cm on the right and 17 square cm on the left, and in B16 as 26 square cm on the right and 19 square cm on the left.

Following thermocoagulation blanching of the coagulated cortex occurred (Plate II B) although vessels larger than half a millimeter in diameter retained the same appearance as before coagulation. No edema was observed during the 20-30 minute period that the dura remained open after coagulation, while the continuity of the pia seemed preserved and no bleeding was caused.

Postoperative Course

Both these patients reacted from anesthesia as they left the operating room. Two hours later they were alert and 6 days later were up and about. The postoperative course was uneventful, and no seizures have so far occurred in either of these patients (9-month follow-up).

Comments on Thermocoagulation of Portions of the Cerebral Cortex of the Frontal Lobe

1. This has proved to be a safe and simple procedure in the 2 cases thus tested, and without ill effect.

2. Since a conservative policy was adopted, the amount of cortex coagulated was rather small.

3. There have been contradictory reports on the changes thermocoagulation produces in the cerebral cortex (Silver and Walker, '47.) The effects, immediate or acute, as well as late or chronic and

permanent, produced by larger amounts of heat than those used in these cases are not well known yet. Research along this line is already in progress but not completed at the present time and will be the subject of a separate report.

SURGICAL THALAMOTOMY

Surgical rather than stereotaxic thalamotomy was carried out in 2 cases: B13 and B14, the procedure being essentially the same in each as described below. Surgical thalamotomy was considered for these 2 badly deteriorated patients by one of us (JLP) because of encouraging results reported by Spiegel and Wycis of Philadelphia (Spiegel, Wycis, Marks, and Lee, '47; Spiegel, Wycis, Freed, and Lee, '48) in the treatment of mental illness by cauterization of the dorso-medial nuclei of the thalamus by means of a human stereotaxic instrument. According to these authors 5 and sometimes more lesions were made in each dorso-medial thalamic nucleus by passing an electrical current through the tip of the needle. Each electrolytic lesion was apparently about 2 millimeters in diameter, so that 5 such lesions would presumably create a defect in the thalamus approximately 1 cm in size. With this in mind an incision about 1 cm in depth and 1 cm in length in the antero-posterior plane was made on each side in the thalamus of our 2 patients. An operative rather than a stereotaxic approach was carried out by us because it was felt that the desired lesion might be placed more accurately under direct vision.

Before embarking on this procedure careful anatomical studies of the fixed brain were made. It was apparent that intraventricular landmarks were sufficient to localize the position of the dorso-medial nuclei, which lie immediately caudal to the caudal margin of the anterior thalamic tubercle, a clearly defined whitish protuberance on the floor of the lateral ventricle close to the interventricular foramen. Additional landmarks were the stria terminalis and the chorioid plexus which cross the dorsal surface of the dorso-medial nucleus. In our 2 patients these landmarks proved to be as distinct as in fixed specimens, so that it was felt the surgical procedure was carried out with reasonable accuracy. The knife cut in each thalamus was directed in a slightly lateral or oblique plane in the hope of ensuring interruption of thalamocortical radiations, a large portion of which project to areas 9 and 10 of Brodmann (Walker, '38).

Operation

PROCEDURE. A right frontal Frazier type flap was turned, the medial margin being placed along the superior longitudinal sinus. The posterior margin extended 3 cm caudal to the coronal suture and the anterior margin about 4 cm rostral to the suture. After opening a

dural flap towards the midline and dividing the exposed superior cerebral veins the right frontal lobe was retracted laterally, care being taken to separate gently the few adhesions binding the 2 frontal lobes together beneath the falx. In spite of this several small veins and arterial channels required cauterization in the region of the cingulate gyri and just superior to them on the right side. The anterior cerebral arteries were both identified as they coursed over the surface of the corpus callosum. They were carefully separated and one small communicating branch between them was cauterized and divided. These arteries were then protected with cotton wall-offs so that each could be retracted toward its own side. The corpus callosum was then easily divided until the roof of the left lateral ventricle was identified and carefully exposed before opening into the ventricle, directly above the interventricular foramen. On enlarging the exposure the chorioid plexus was clearly seen, and the head of the caudate nucleus, the anterior tubercle of the thalamus, stria terminalis, and the dorso-medial portion of the thalamus. The chorioid plexus contained 2 large vessels, 1 arterial and 1 venous. The plexus was cauterized for a distance of about 1 cm at a point beginning at the caudal margin of the anterior tubercle of the thalamus. An incision was then made into the thalamus about 1 cm in length in the AP plane and about 1 cm in depth, at a region corresponding to the cauterized portion of the plexus. The incision was made in a slightly oblique direction laterally, with a No. 11 scalpel blade marked at 1 cm. There was no significant oozing so that it was possible to turn promptly to the other ventricle and carry out the same procedure. One silver clip was placed in each thalamic incision as a marker.

In this other case (B14) the incision was made about 2 mm closer to the midline; that is, along the medial margin of the chorioid plexus and perhaps 1 mm nearer the tubercle than in case B13. Otherwise the technique in each case was almost identical. At the end of the procedure the wounds were filled with clear saline (and a weak penicillin solution) which remained as clear as spring water despite coughing purposely induced to test hemostasis.

The wounds were then closed in layers in the usual fashion without drains. A careful check of vital signs by the anesthetist during and after each thalamic incision showed no change in pulse, respiration, color, or blood pressure.

COMMENT. There were no significant complications in either of these 2 patients aside from temporary left-sided hemiplegia lasting a few days in each. This was expected to follow retraction of the right cerebral hemisphere and was not attributed to the thalamic lesions. Evidently the latter were placed as intended, judging from postoperative pneumoencephalograms (Plate II C & D) which showed the relation of the silver clip markers to the floor of the lateral ventricles. It should also be noted that there were no permanent postoperative sensory changes which would occur were the lesions made in a more caudal portion of the thalamus.

It cannot be denied that this is a surgical procedure of considerable risk, so that it does not seem worth-while repeating unless significant psychiatric improvement occurs in these cases.

TRANSORBITAL LOBOTOMY

In 9 cases (cases B17, B18, B19, B20, B21, B22, B23, B28, and A10) transorbital lobotomy (Freeman, '48a) (Freeman, '48b) was performed by Dr. Walter Freeman. Each patient was first rendered unconscious with 2 electrical shocks. After lobotomy was performed on one side, another electrical shock was given and a similar procedure was performed on the other side. The average current used for electrical shock was 90-110 volts administered for 0.4 second.

In the first eight cases the transorbital lobotomy was done with the following technique: The eyelid was pinched between thumb and forefinger and the tip of the transorbital leucotome[2] was inserted into the conjunctival sac between the eyeball and the upper lid so that it would rest against the highest point of the roof of the orbital cavity. The shaft was then set parallel with the bony ridge of the nose. The leucotome was then thrust through the orbital plate into the frontal lobe by a sharp tap. After being driven to a depth of 4 cm the handle of the leucotome was moved laterally as far as the orbital margin would permit. It was then returned to a slanting position slightly medially and advanced to a depth of 7 cm. At that point it was displaced 15 degrees laterally and subsequently 15 degrees medially from the parasagittal plane. The instrument was then withdrawn and a pressure dressing applied over the closed eyelids.

In the ninth case (B10A) the technique was modified by an additional cut. After completion of the frontal incisions at a depth of 7 cm, with the handle of the leucotome deviated outward 15 degrees, it was displaced strongly in an upward or dorsal direction so as to add a vertical section of the white matter toward the mediobasal portion of the frontal lobe to the horizontal incisions.

Topectomy Following Previous Cortical Ablation

CASE A8. On May 19, 1947 (Columbia Greystone Associates, '49) bilateral ablation of the middle frontal gyri had been carried out. As pointed out elsewhere (p. 30), the patient postoperatively had failed to show improvement as regards his psychotic behavior, and in addition became subject to convulsive seizures. Because of his continued psychotic symptoms the present psychiatric discipline recommended bilateral prefrontal lobotomy. The neurosurgical discipline felt, however, that lobotomy would disconnect a greater proportion of each frontal lobe than would be sacrificed were cortical ablation carried out, limited to the portions of areas 9 and 10 of Brodmann that had not been removed at his first operation. Cortical ablation of the residual parts of areas 9 and 10 was therefore carried out as described below, with the understanding that if necessary, prefrontal lobotomy might subsequently be necessary.

2. The transorbital leucotome is made by H. A. Ator, 5332 Twenty-ninth St., N.W., Washington, D. C.

It may be observed that the presently described re-exploration of the frontal lobes demonstrated relatively little evidence of widespread gross pathological changes as the result of the previous initial cortical ablation, although at the site of the latter, a cortical scar existed together with local adhesions between the scar and the overlying dura. It was also apparent that neither middle frontal gyrus had been wholly extirpated at the time of the original operation, and that each initial excision of cortex in this case was of course closer to the motor area than the cortical ablations used by Pool, Heath, and Weber in their more standardized rostro-medial topectomies, (Pool, Heath, Weber, '49, pp. 335, 344) which may account, at least in part, for the frequency of convulsive seizures in this patient.

Operative Procedure

Under the usual anesthesia procedure used in this series the previously made frontal bone flaps were reopened (Columbia Greystone Associates, '49) the present dural openings being limited to the rostro-dorsal aspect of each scar only. It was noted that dural adhesions between the cortical scar on the left seemed greater than those on the right, and that the cortex was yellowish and looked somewhat hypervascular above the former excisions (the only part of the cortex visualized). Apparently a satisfactory excision of the middle frontal gyrus had been carried out on the left side which left a portion of cortex representing the superior frontal gyrus (about 2.5 cm in width). This part of the cortex looked quite normal both on its surface and on cut section, and its arterial supply obviously came from branches of the anterior cerebral artery.

No attempt was made to expose the ventral or caudal margins of the scar on the left side by separating the dural adhesions, these portions of the previous excision being left intact. The superior frontal gyrus including the frontal pole and all cortex thought to represent the residual portion of areas 9 and 10 of Brodmann was excised, together with the anterior third of the orbital gyri (area 11). All of this cortex looked grossly normal. A clean excision having been accomplished, the dura was then opened on the right side, where it was at once apparent that the lesion was not exactly the same as that on the left, for there was a wider zone of intact cortex between the previous excision and the falx cerebri measuring about 4 cm in width. Indeed, it appeared that the superior portion of the right middle frontal gyrus had been spared. All of the intact cortex up to the edge of the scar looked entirely normal except for a few very fine adhesions easily separated by gentle blunt dissection. The site of the previous excision was marked by a smooth line of yellowish glistening cavity of small size. The previous scar was not exposed except along the rostral two thirds of its superior border. On cut section the cortex and white matter on the right seemed grossly normal.

The present excision was carried out so as to include all of areas 9 and 10, much as on the right side, and part of the rostral extent of the orbital gyri (area 11). Although the margins of each cavity were clean and dry, oxidized cellulose (Hemo-pak oxidized cellulose) was placed within them to ensure hemostasis. Before closing the dura completely saline and 5 cc penicillin solution (1000 units per cc) were instilled on each side. The bone flaps were then replaced, anchored with periosteal sutures, and 4 small tantalum discs were then used to cover the 4 anterior burr holes. It should be noted that the margins of each excision were outlined with silver clips used for hemostasis, and that the electro-cautery was very sparingly used. The specimen from the right side was placed immediately in carbon dioxide snow for enzyme studies while the left was placed immediately after excision in 10 per cent formalin solution.

Topectomy After Previous Bilateral Prefrontal Lobotomy

CASE MSH. October 19, 1948:

Procedure. A coronal incision was made 1 cm behind the coronal suture and the scalp flap retracted anteriorly. The trephine openings for the previous lobotomy were identified and used for the bone flap. A bifrontal bone flap was turned 9 cm in the AP dimension above the midline, 7 cm to the right of the midline and 6 cm to the left of the midline. Except for the scar tissue found at the level of the previous opening made for the lobotomy there was no other definitely pathological finding, except that the scalp and dura were unusually vascular.

It should be remarked that the trephine for the previous lobotomy was placed at the line of the coronal suture 6 cm from the midline at each side.

Photographs were taken to show the relations of the previous trephine opening on the right to the coronal suture, the coronal suture and the midline being marked with black threads.

On opening the dura there were extremely large veins on both sides, about 5 mm in diameter, of the 3 on the left side, one was near the frontal pole, one on the medial aspect of area 9 communicating with the falx, and one more posteriorly which was not as large as the others. On the right side there was one exceptionally large vein rostrally like that on the left and several smaller ones more posteriorly. The large veins on each side seemed larger in diameter than those of a normal brain.

The dura was adherent to the cortex for a zone about 1 cm in diameter beneath the site of each lobotomy scar. The cortex elsewhere had a somewhat atrophic appearance with some excess cerebrospinal fluid and slight cloudiness of the pia arachnoid. The surface of the cortex on each side seemed to have more small surface vessels than a normal brain, and in addition the cortex felt unusually firm on palpation.

There were unusually dense adhesions between the falx and the medial surface of each frontal lobe for a zone of about 2 cm in diameter at the mid-portion of the exposure (corresponding roughly with the medial aspect of area 9).

In this patient small arteries not over 1.5 mm in diameter were often unusually difficult to seal with the electro-cautery, especially those near the lobotomy scars.

The approximate boundaries of areas 9 and 10 were marked with black silk thread on each side before resection. Resection was carried out largely with silver clips and cautery and included the frontal pole on each side and probably the most rostral portion of area 11. Caudally the resection of cortex included the superior half of each lobotomy incision. The lobotomy incisions were apparently made through the caudal part of area 9 just above area 44, as judged by their relation to the Sylvian fissure and precentral gyri.

The subcortical portion of the lobotomy scars was thickest along a plane just rostral to each coronal suture where the lobotomy incisions (which seemed adequate) had been made, and the white matter was so tough and fibrous that it had to be cut with scissors, and seemed unusually vascular. This tough scar tissue extended for a distance of about 2 cm rostral and caudal to the line of each lobotomy incision. Most of the upper or dorsal half of this scar tissue was removed, while each cortical resection was extended about 2 cm caudal to the lobotomy incisions. On the left side the pia 2 cm below the surface was yellowish and thickened for a distance of about 2.5 cm caudal to the lobotomy incision, as if some bleeding had occurred between the sulci there after the lobotomy. In addition the gray matter was yellowish around the lobotomy scar for a distance of about 1 cm while the gray matter elsewhere on cut surface

had a dirty, dull gray appearance that seemed distinctly abnormal as far rostrally as each frontal pole.

The zone of resection was well marked with silver clips on the left side, fewer clips being used on the right. Each wound was dry at the time of closure. A small amount of oxidized cellulose and penicillin solution was used on each side as in previous cases. The dura was then closed in water-tight fashion and the bone flap and scalp closed in the usual manner, 3 tantalum discs being used to close the 3 anterior burr holes. The patient's condition was satisfactory at the end of the operation.

Each block of resected tissue measured 8 cm along the midline, 5.5 cm along the caudal border, 4.5 cm along the rostral border, and 3 cm between the medial margin of area 46 and the falx. The depth was about 2.2 cm at all points.

Comment. Operation was carried out as described in the hope that cortical ablation of areas 9 and 10 of Brodmann bilaterally might prove beneficial where lobotomy had failed, on the grounds that the lobotomy had perhaps not adequately interrupted the association fibers and subcortical connections of areas 9 and 10. Since the lobotomy incisions seemed entirely adequate, one would expect little in the way of postoperative behavior alteration as the result of topectomy in this case.

It seems worth noting that evidence of gross changes in both the gray and the white matter seemed to have taken place as the result of lobotomy not only at the site of each lobotomy incision but also for a zone of 2 or more cm from the incisions.

Chapter 4

GENERAL MEDICAL CONDITION, INCLUDING HEMATOLOGICAL AND PHYSIOLOGIC FINDINGS

Gilbert H. Glaser, I. Melbourne Greenberg,
Bruce Ralston, and Katherine Chaltas

INTRODUCTION. This phase of the project includes a survey of the general medical condition of the patients, an analysis of clinical laboratory findings, especially hematological, and a study of stability of the autonomic nervous system and carbohydrate metabolism as determined by means of special tests.

Twenty-three patients were studied preoperatively and 22 of these postoperatively (n.b. one postoperative death). Preoperative control observations were obtained during the 2-month period prior to operation. Postoperatively, 4 test periods were utilized: frequent observations were made during the first month, and at monthly intervals thereafter through the third postoperative month. The preoperative control data for each test were analyzed statistically to establish the degree of variation. The postoperative data were grouped into the 4 operative categories: venous ligation (group A: 11 cases)[3], thalamotomy (group B: 2 cases), thermocoagulation (group C: 2 cases), and transorbital lobotomy (group D: 7 cases). Because there are only 2 cases in groups B and C only suggestive trends can be shown relative to the effects of those cerebral lesions. These lesions while essentially involving the prefrontal cortex and region of the medial nuclear group of the thalamus, are non-specific and accurate inference with regard to the different cerebral areas involved cannot be drawn from this material. However, the results of these procedures will be compared with those of topectomy, in which effects due to involvement of particular regions have been noted.

All patients received the psychiatric diagnosis of schizophrenia. The group was too small to compare adequately the subcategories, but an attempt was made to correlate physiologic changes with the estimated range of affective display in each case. In general, this affect was regarded as minimal, blunted, or channelized.

3. The cases receiving venous ligation are grouped together. In the analysis of the data in this study, no significant differences in hematological responses, blood pressures, autonomic tests, and carbohydrate metabolism appeared between the groups that had venous ligation 5 cm or 2 cm posterior to the coronal suture.

GENERAL MEDICAL CONDITION OF THE PATIENTS

The cases were screened preoperatively to exclude complicating medical conditions, particularly pulmonary and cardiovascular. There were 17 females and 6 males in the group studied, ranging in age from 26 to 52 years, with 14 patients in the 30-40 year age span. One patient (B18) had a history of regional ileitis with hemicolectomy performed in 1940 and no symptoms since. Three patients (B2, B7, B8) had labile blood pressures frequently fluctuating into minor elevations above 140/95, and are regarded as cases of prehypertension or vasomotor instability. One patient (B4), age 50, had a history of rheumatic fever at age 24 and had evidence of mild mitral valve involvement. There was no history of cardiac decompensation or other rheumatic complication.

All the other patients had a completely negative medical history. All the patients were in good physical condition prior to operation.

Postoperatively, (see also Chapter 3), there were medical complications in 3 cases only. There was one death (patient B4) 4 days after venous ligation, due to intracerebral hemorrhage. It was felt that this was a direct result of the operative lesion and not related to the old rheumatic history (v.s.). Two patients, B7 and B10A, developed wound infections with a resistant strain of Staphylococcus aureus which responded only partially to antibiotic agents (sulfonamides, penicillin, streptomycin, and bacitracin). Reoperation was necessary in both cases, with removal of the osteomyelitic bone flap, before the infection could be controlled.

MENSTRUAL HISTORY. Three of the female patients were in menopause (B4, B5, B8: age 50, 51, and 47 years respectively). One patient was still having regular menstrual periods at age 52 years (B10A). Another, (B12), age 26 years, was amenorrheic (cause undetermined). This continued throughout the period of postoperative observation. The remaining 12 women were having normal cycles. Observations during the 3-month postoperative period revealed no essential changes in the menstrual cycles except for patient 22A who missed one period immediately following transorbital lobotomy.

WEIGHT CHANGES. Each patient was weighed at weekly intervals preoperatively and postoperatively for the first month, then monthly thereafter. During the 2-month preoperative period, 8 patients showed losses of from one to 10 pounds; 14 patients showed a gain of one to 10 pounds, and the weight of one remained constant.

Postoperatively, the patients in groups A, B, and C showed average reductions of from 7 to 10 pounds during the first week, with a return to previous values by the third to fourth week. This persisted during the next 2 months of observation. Two patients, B12 and B22A, showed a persistent slight gain which began preoperatively. With the exception of patient B22A, those cases receiving transorbital lobotomy

(group D) showed no significant change in weight postoperatively. Three patients (B1, B3, B14) showed a tendency to overeat. The appetites of most patients improved postoperatively.

There was no correlation between any change in weight, even slight, with the type of operation or the patient's postoperative response to it. These findings are similar to the results following topectomy (Heath, Carpenter, Gass, and Weber, '49).

Hematological Findings

The following hematological constituents were determined pre- and postoperatively on all patients: hemoglobin, erythrocytes, hematocrit, reticulocytes, leucocytes, and lymphocytes, and erythrocyte sedimentation rate. Preoperative determinations were performed at regular intervals during the 2-month control test period. Postoperatively, frequent determinations were performed during the first month (at 4-7 day intervals) and at monthly intervals thereafter for 3 months. The preoperative data were analyzed for the group as a whole to establish the degree of variation (fig. 12) and the postoperative data (i.e., mean values) charted for each of the operated groups (figs. 12, 13, 14, 15). All the preoperative values fell within the normal range of distribution (Wintrobe, '47, p. (67).

PREOPERATIVE CONTROL PERIOD DATA (23 CASES)

TEST	NUMBER OF DETERMINATIONS	RANGE	M AND σM	SD	REMARKS
HEMOGLOBIN	111	11-16	13 5±0 2	1 0	Gms HADEN-HAUSSER
ERYTHROCYTES	105	3 1-5.7	4.52±0 07	1033	MILLION
LEUCOCYTES	98	5000-14000	8300±320	1600	TOTAL
LYMPHOCYTES	98	2400-3800	3000±42	209	TOTAL
RETICULOCYTES	69	0.5-1.9	1 0±0 03	0.17	% SLIDE METHOD
HEMATOCRIT	45	32-43	38±0 6	2 9	SANFORD-MAGATH
ERYTHROCYTE SEDIMENTATION RATE	70	1-26	8±0 8	4 2	mm/Hr WESTERGREN
BLOOD SUGAR	69	55-100	75 5±1 7	8.3	Mg % FASTING
CIRCULATION TIME	70	9-18	13±0.3	1 4	Secs DECHOLIN
BLOOD PRESSURE (SYST)	136	80-160	120±3	17	MORNING RESTING STATE READINGS
BLOOD PRESSURE (DIAST)	136	55-110	77±2	12	

M=MEAN ; σM=STANDARD ERROR OF MEAN ; SD=STANDARD DEVIATION

FIG. 12. Degree of variation in preoperative period among patients subsequently operated upon.

BLOOD TRANSFUSIONS. Hematological findings were influenced by the blood transfusions received by patients following venous ligation, thalamotomy, and thermocoagulation. No transfusions of blood or plasma were given after transorbital lobotomy. With the exception of patient B3, all of the patients in the first 3 groups received 1 to 4 transfusions of 500 cc each of whole blood during the first postoperative

week. Only 4 other transfusions were made outside of this period: one to patient B1 in the second week, 2 to B10A in the third week. In all, 25 transfusions were given to 14 patients during this period. No untoward reactions occurred.

HEMOGLOBIN:

Method. The Haden-Hausser hemoglobinometer was used for all determinations and values expressed as grams/100 cc blood.

Results. Preoperatively 111 determinations were performed on 23 patients. A mean value of 13.5 ± 0.2 gms (SD 1.0)[4], with a range of 11-16 gms, was found. This variation is within normal limits and corresponds to other determinations on state mental hospital patients.

Postoperatively. After venous ligation an initial mean fall to 10.4 gms during the first week was followed by a rise to 13.0 gms (fig. 13). Another unexplained fall to 10.9 gms occurred in the third week in association with a parallel erythrocyte drop (v.i.).

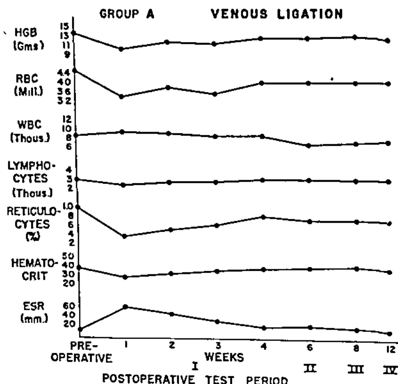


FIG. 13. Hematologic findings prior to and after ligation of the frontal superior cerebral veins.

4. All numerical data in this chapter are expressed as: mean ± standard error of the mean (standard deviation in parentheses).

After thalamotomy, there was an average initial mean fall to 12.0 gms postoperatively with a gradual rise to 13.5 gms by the third month. *During the third postoperative week a transient fall to 11 gms* occurred in association with parallel diminution in other blood constituents (fig. 14).

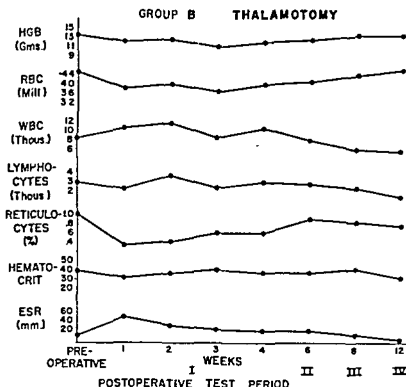


FIG. 14. Hematologic findings following thalamotomy.

After thermocoagulation, a delayed mean fall to 9.5 gms occurred in the third week (fig. 15), with gradual rise to normal values by the third month.

After transorbital leucotomy, no significant changes occurred in the hemoglobin of the 7 patients (fig. 16).

ERYTHROCYTES. During the preoperative control period 105 erythrocyte counts were performed on the 23 patients. A mean value of 4.52 ± 0.07 (SD 0.33) million cells were found. This variation is within normal limits and corresponds to other determinations on state mental hospital patients (Sagert, Mettler, Emmel, Rothfield, Carpenter, Longley, Weber, and Gass, '49). The counts ranged from 3.1 to 5.7 million, *the low value occurring only twice.*

Postoperatively. After venous ligation (fig. 13), an initial mean fall to 3.4 million during the first week was followed by a gradual rise, although a slight fall to 3.5 million again occurred by the third week. At the end of 3 months the erythrocyte count reached a mean of 3.9 million for the group.

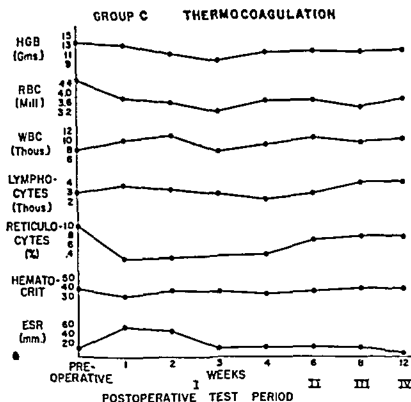


FIG. 15. Hematologic findings following thermocoagulation.

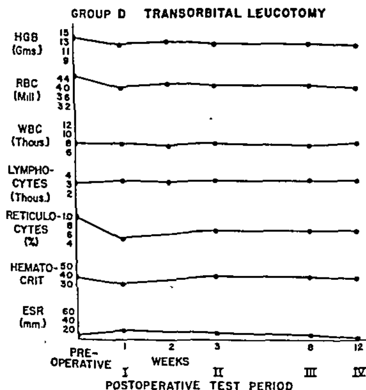


FIG. 16. Hematologic findings following transorbital leucotomy.

After thalamotomy (fig. 14), a mean fall to 3.1 million occurred by the third postoperative week, with slow rise to but 3.3 million by the end of the third month.

After transorbital leucotomy (fig. 16) no significant deviations in erythrocyte count occurred.

HEMATOCRIT. Preoperatively, in 45 determinations using the Sanford-Magath method, a mean of 38 ± 0.6 per cent (SD 2.9) was found in 23 patients. This is within normal limits of variation.

Postoperatively. Following venous ligation (fig. 13) a mean fall to 29 per cent occurred in the first week with gradual rise to 40 per cent by the end of 3 months.

After thalamotomy (fig. 14), the initial mean fall to 32 per cent during the first week was followed by a rise to 41 per cent by the third week. This level was maintained.

After thermocoagulation (fig. 15), the mean hematocrit fell to 30 per cent during the first week with gradual rise to preoperative level by the second week.

The hematocrit levels paralleled, in general, the degree of anemia occurring postoperatively.

Transorbital leucotomy produced no significant changes in hematocrit levels (fig. 16).

RETICULOCYTES:

Method. All counts were performed by the same individual, using the "dry" slide method with an 0.5 per cent solution of brilliant cresyl blue in absolute alcohol. A drop of capillary blood was placed on a slide and mixed with the dried film of stain. A streak smear was made and counted after 5 minutes. The percentage of reticulocytes in 1000 erythrocytes was determined.

During the preoperative control period 69 determinations were performed on the 23 patients (3 per patient). A mean percentage of 1.0 ± 0.03 (SD 0.17) was found in a range of 0.5 per cent to 1.9 per cent. This is within the normal range of variation. The mean preoperative value of the patients in a similar state hospital patient series was 0.87 per cent (Sagert, et al., '49).

Postoperatively, in the first week following venous ligation, thalamotomy, and thermocoagulation the mean reticulocytes for each group fell to 0.3 per cent (figs. 13, 14, 15). This is regarded to be a significant decrease. Normal values were attained by the second week after venous ligation, by the third week after thalamotomy and by the second month after thermocoagulation. Following transorbital leucotomy, the reticulocytes remained within normal limits.

There is evidence, therefore, of a possible suppression of reticulocyte response after venous ligation and thermocoagulation of prefrontal cortex, and after thalamotomy. The role of transfusions during this period is not clear.

Mettler ('43) noted reticulocytosis following bilateral removal of frontal cerebral cortex from dogs. The response was almost immediate and reached maximum values in about 4 days. This was followed by lesser showers and some slight instability of values. There was no evidence of hemoconcentration in these animals. Following topectomy (Sagert, et al., '49), there was evidence of suggestive reticulocytosis after removal of granular frontal cortex. In the present series the absence of reticulocytosis and possible suppression might be related to the difference in operative procedure, i.e., ablations were not performed. Further studies are necessary to clarify this subject.

LEUCOCYTES AND LYMPHOCYTES. These blood constituents were followed as indicators of tissue destruction (Sagert, et al., '49) and infection and for possible correlation with change in emotional status (Milhorat, Small, and Diethelm, '42).

Preoperatively, 98 counts were made on the 23 patients at regular intervals during the 2-month control observation period. The mean results for the group as a whole are presented in Table 1. The leucocyte counts ranged from 5000 to 14,000, with mean at 8300 ± 320 (SD 1600). There was no correlation with affective status and no infections were noted in any case. The mean percentage of lymphocytes was 35.7 ± 1.0 per cent (SD 4.8) and the mean total lymphocytes 3000 ± 42 (SD 200). A tendency toward unexplained leucocytosis (10,000-15,000) has been noted previously in hospitalized psychotic patients (Bowman and Raymond, '29; Kasanin, '34; and Breutsch, '47).

Postoperatively. Following venous ligation (fig. 13) an insignificant leucocytosis occurred in the group as a whole. Patients B7 and B10A ultimately developed wound infections necessitating reoperation. Slight leucocytosis occurred in these patients. The percentage of lymphocytes for the group rose from an initial postoperative value of 29 per cent to 50 per cent by the second postoperative month. The total lymphocyte rise varied from a mean of 2400 cells (SD 566) to 3100 cells (SD 1000), or figures within normal limits. The wide range of variation indicates that no significant change in lymphocytes occurred.

After thalamotomy a slight leucocytosis occurred during the first 4 weeks, (fig. 14). This was associated with a slight relative and actual lymphocytosis. The highest values occurred during the second postoperative week. Both patients were hemiplegic at this time and were just becoming ambulatory.

Following thermocoagulation a slight leucocytosis occurred during the second postoperative week (fig. 15). There were no significant deviations in percentage or total lymphocyte counts.

After transorbital lobotomy no significant changes in total leucocytes, and percentage or total lymphocytes occurred (fig. 16).

ERYTHROCYTE SEDIMENTATION RATE (ESR). This test was performed as an index of tissue destruction.

Method. The Westergren method was used: 1.6 cc of venous blood was mixed in a tube containing 0.4 cc of 3.7 per cent sodium citrate. The Westergren pipette was filled and placed upright in a special rack. Readings were taken at the end of one hour. The entire procedure was completed within 2 hours after obtaining the blood sample.

During the preoperative control period, 70 determinations were performed on the 23 patients, producing a mean rate of 8.1 $\pm$ 0.8 (SD 4.2) mm/hr. This is well within normal limits. Previous studies on *schizophrenic patients found normal sedimentation rates* (Shottky, '31; Freeman, H., '33).

The postoperative changes for each group are charted (figs. 13, 14, 15, 16). There was an immediate increase in the ESR following venous ligation, thalamotomy, and thermocoagulation. Return to normal values occurred by the fourth week following venous ligation and by the third week after thalamotomy and thermocoagulation. The postoperative infections of patients B7 and B10A caused the ESR to remain elevated. These values are not included in the charted means. The ESR increases are much greater than could be accounted for by the postoperative anemia.

The sedimentation rate did not show any significant variations following transorbital leucotomy. Slight elevations occurred in 2 patients which returned to preoperative values within one week.

Following topectomy (Sagert, et al., '49), there was no correlation between erythrocyte level, leucocyte and lymphocyte counts and the location of cortex removed. Erythrocyte sedimentation rates were not performed in that initial study.

CIRCULATION TIME. The circulation time (arm to carotid branches) was measured using Decholin Sodium (sodium dehydrocholate). Five cc were injected into the median basilic vein at the elbow. The time of appearance of the characteristic bitter taste was noted by the patient's statement or facial expression. The normal range is usually given as 9-18 seconds (Fishberg, '40, p. 148).

During the preoperative control period, 70 determinations were performed at regular intervals on the 23 patients. A mean circulation time of 13 $\pm$ 0.3 (SD 1.4) seconds was found. The range was between 9 and 18 seconds. All values were within normal limits.

Previous studies on schizophrenic patients using intravenous sodium cyanide solution found the circulation time either prolonged or more variable (Freeman, H., '38), or within normal limits (Finesinger, Cohen, and Thomson, '38).

Postoperatively, after venous ligation, thermocoagulation, and transorbital leucotomy the circulation times remained within the normal range at all times. Following thalamotomy the circulation time was prolonged changing from 12 to 18 seconds. This occurred at a time when the patients were bedridden, hemiplegic, and may have had a slower reaction time. As this situation cleared, the circulation time returned to the normal preoperative values.

BLOOD PRESSURE. Blood pressure readings were taken on all patients during the pre- and postoperative periods.

Method. All determinations were by the sphygmomanometric method using a mercury manometer. The readings were taken in the morning before the patient was out of bed. All patients were ambulatory between readings except during the immediate postoperative period. Diastolic values refer to the point at which the sound disappears. This point is regarded as sharper and less liable to error.

Three preoperative control determinations were obtained on all patients and the values averaged (fig. 12). The range of variation was 80/55 to 160/110 with mean at 120/77. The high values were due to the 3 patients with labile pressures previously maintained. The lower values are not uncommon in a group of schizophrenic patients.

Postoperatively, blood pressures were determined at the end of 2 weeks and during the second and third months in the standard test periods. The values during the first 2 postoperative weeks were not included since it was felt that the immediate postoperative changes in blood pressure reflected the general operative trauma of craniotomy, shock, and enforced bed rest.

The patients in group A (venous ligation), although showing immediate postoperative hypotension, had rapid return to preoperative values by 2 to 4 weeks postoperatively. The 3 patients with labile blood pressures preoperatively showed similar fluctuations after operation, with case B7 showing more frequent and persistent elevations (as high as 180/110) for 2 months. The 2 patients undergoing thalamotomy showed a slight fall in systolic and slight rise in diastolic pressures lasting approximately 2 months. These cases had severe postoperative shock reactions and the diastolic elevation may represent persistent peripheral vasoconstriction. The 2 patients in group C (thermocoagulation) had slight systolic and diastolic depressions lasting longer than the immediate postoperative period. All the cases in groups A, B, and C showed a return to their preoperative control levels by the third postoperative month. The patients receiving the transorbital lobotomy (group D) showed no significant deviations in blood pressure postoperatively.

The above findings parallel those after topectomy. There was no correlation with site of operation or amount of cortex removed, and the temporary changes noted postoperatively with topectomy, or with the type of operation in this series. Transitory falls in blood pressure have occurred after classical lobotomy, but these too, revert to normal after a few months (Freeman, W. and Watts, '42; Greenblatt, Arnot, Poppen, and Chapman, '47).

One patient reported by Greenblatt, et al. ('47), developed a higher blood pressure postoperatively and was found to have had a previous history of hypertension (n.b. case B7 cited above). These investigators also noted transient falls in the blood pressure of 8 hypertensive subjects postlobotomy, with subsequent return to preoperative levels.

The effect of operative procedures on the brain in cases of hypertensive cardiovascular disease is still to be evaluated adequately.

Autonomic Tests

During recent years much attention has been devoted to the relationship between the frontal lobes and the autonomic nervous system. This has been reviewed recently by Kennard ('37, '44) and Mettler ('48b). Lesions and stimulation of the orbital areas, areas 24, 4, and 6 and possibly areas 9 and 10, produce changes in autonomic nervous system function reflected in peripheral phenomena which can be measured, i.e., pupillary reactions, pulse, blood pressure, and respiratory rate changes, edema, gastrointestinal phenomena, changes in piloerection, skin temperature, sweating, and electrical skin resistance. Both excitatory and inhibitory phenomena have been noted. Two studies have been devoted to the analysis of autonomic responses to drugs after prefrontal leucotomy. Reitman ('45) using neostigmine, eserine, ephedrine, and amphetamine and noting clinical responses to the drug found diminished responses and a prolonged reaction time. Rinkel, Greenblatt, Coon, and Solomon ('47) used ephinephrine intravenously (0.05 mg) and found an "overreaction" of the blood pressure response. To evaluate the parasympathetic system they used carotid sinus stimulation with simultaneous electroencephalographic and electrocardiographic recording. Again an intensified response occurred in lobotomized patients. These authors feel that the subcortical sectioning of the frontal lobes produced loss of "cortical inhibition" of the autonomic nervous system.

In the present study, autonomic nervous system responsiveness was measured by testing the response of the blood pressure to stimulation by epinephrine, as sympathomimetic agent, methacholine chloride as parasympathomimetic agent, and the cold pressor test as a means of noting response to a mixed stimulus, predominantly psychic (White, B. V. and Gildea, '37), but also involving local vasoconstriction. The duration of the response, i.e., time of blood pressure return to normal, was also measured. Also, with the methacholine test, measurement of the electrical skin resistance (SR) of the palmar and dorsal surfaces of the hand was accomplished.

EPINEPHRINE TEST. *The patient was placed in a resting, reclining* position and blood pressure determined on one arm until stationary values were obtained. 0.05 mg epinephrine was injected intravenously and blood pressure measured at 30 seconds, and at one minute intervals thereafter. The composite average results of 2 preoperative tests and the 4 postoperative tests are shown in fig. 17. All patients showed measurable increases in systolic and diastolic pressures during all tests. There were no untoward reactions. Blanching of the skin, particularly of the face, occurred at the height of the hyperten-

sive response. Preoperative control values for the group as a whole gave a mean systolic change of 55 ± 2.3 mm Hg. (SD 11.5) and a mean diastolic change of 22.6 ± 2.3 mm Hg. (SD 11.3). The patients with labile blood pressures gave responses within the average range.

Previous investigators have studied the effects of epinephrine injection in schizophrenic patients. Kanner ('28) found the usual pressor response diminished or absent and postulated autonomic imbalance in schizophrenia, with parasympathetic dominance. Northcote ('29) found no differences between schizophrenics and normals. Contradictory results in these investigations might be due to the use of the subcutaneous route, and lack of uniform dosage. H. Freeman and Carmichael ('35) tested the response to intravenous epinephrine injection, as done in the present study. They found a mean systolic rise of 43.8 mm and diastolic rise of 1.7 mm in schizophrenic patients, and mean systolic rise of 56.2 mm and diastolic rise of 0.5 mm in normal controls. There was no correlation with psychiatric status. The present preoperative control values are in essential agreement with these latter control studies except for the greater diastolic response. This study

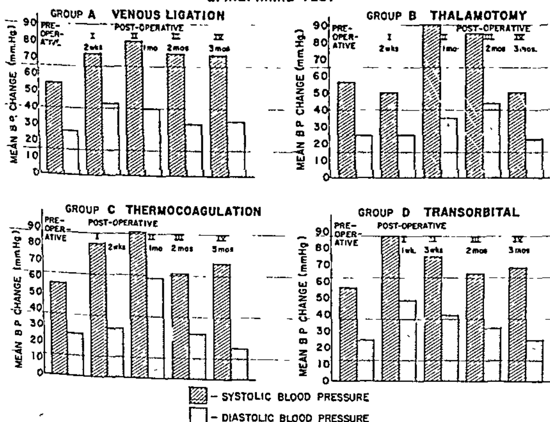


FIG. 17. Responses to injection of epinephrine following various indicated procedures.

does not confirm the concept of hyporeactivity of sympathetic nervous system responses in schizophrenic patients.

The postoperative responses to epinephrine injection are shown in fig. 17. In general, these are of a greater degree postoperatively than preoperatively in all groups. In all cases there was beginning diminution of the response in the third month, although it still remained greater than normal. There was no evidence of resistance to epinephrine stimulation. This, therefore, is in agreement with the work of Rinkel et al. ('47).

These data indicate hyperreaction of the sympathetic nervous system to a direct stimulus after these operative procedures and suggest that cortical inhibitory functions have been removed.

METHACHOLINE TEST. This test was performed in similar fashion to the epinephrine test. The patient was placed in a resting, reclining position and the blood pressure measured on one arm. The electrical skin resistance (SR) of the opposite (usually the left) dorsum and palm of the hand was measured concomitantly. This measurement of skin resistance is regarded to be a reliable indicator of sweat gland activity (i.e., cholinergic responses). The meter used was a modification of the Jasper ('45) dermohmmeter. This instrument enables a wide range of quantitative measurements. A constant-atmosphere room was not available but it was felt that the results were repeatable to a significant degree (within wide limits) and that gross changes could be determined and compared. Diurnal and body surface variations were not determined at this time. Attention was paid to the resistances of the dorsum and palm of one hand. These surfaces apparently respond differently to stimuli (Richter, '29; Richter, Woodruff, and Eaton, '43), but the mechanism of these differences has not been established. The measurement in this study was used only as a gross estimate of a cholinergic response. Special silver electrodes were strapped to the dorsum and palm and careful attention was paid to electrode size, position of electrodes, and tightness of contact. The area under the electrode was kept free of excessive accumulations of sweat in all cases. After stationary control values of blood pressure and skin resistance were obtained, 25 mg of methacholine were injected subcutaneously and measurements taken at minute intervals for 5-10 minutes, then at expanded intervals (2-5 minutes) until a return to the control level or newly established baseline was achieved (usually in 20-30 minutes). The duration of this response was measured. Preoperatively the test was performed 46 times on 23 patients (2 tests per patient). There was no correlation between the magnitude and type of fall of skin resistance and the basic control value or degree of affective display of any patient. The skin resistance of the dorsum always fell in much greater magnitude than that of the palm. In 30 per cent of the tests, this fall of dorsal skin resistance reached a value lower than that of the palm. This occurred on several tests with apparently no relation to atmospheric conditions and bore no relation to the psy-

chiatric status or later operative procedure. This phenomenon of "reversal" is to be investigated further. At present it has no adequate explanation. Differences in autonomic innervation of the 2 surfaces will have to be studied. The 2 types of response are shown in figure 18. Figure 19 indicates the magnitudes of the mean maximal changes in systolic and diastolic blood pressure and in skin resistance. These responses showed a relatively wide range of variation: systolic blood pressure fall ranged from 8-100 mm, mean 37 $\pm$ 4.2 (SD 21); diastolic blood pressure fall ranged from 0-65 mm, mean 35 $\pm$ 2.5 (SD 12.7). These changes are within the normal range. There have been previous studies of the blood pressure response to methacholine in schizophrenic patients and the reactions were found to resemble those of normal subjects (Myerson, Loman, and Dameshek, '37); Dameshek, Loman, and Myerson, '38; Altman, Pratt, and Cotton, '43). Only in hebephrenic patients did the responses suggest deficient autonomic regulation (Altman, Pratt, and Cotton, '43). The number of patients in most series, including the present, is too small to note statistically significant differences between normals and the subgroups of schizophrenia. The skin resistance showed a preoperative basic control range of 250 K to 2200 K for the dorsum and 55 K for the palm. This is within the normal limits of variation as noted in previous studies (Richter, '28). This variation, however, showed a flat distribution curve. The true normal variation could not be determined without the use of constant atmospheric conditions and the present values thus have only a relative significance.

There were no severe reactions to the drug. Symptoms of warmth, nausea, flushing, chilly sensations, salivation, coryza, generalized sweating, increased intestinal motility, weak and irregular pulse appeared within one minute (average 30-40 seconds) and lasted an average of 9 minutes preoperatively concomitantly with the changes in blood pressure and skin resistance. Only once did involuntary micturition occur. The patients occasionally complained of the unpleasant sensations, but undue anxiety appeared only rarely. The symptoms produced by the drug were inconsistent and postoperatively, several changes were noted, as compared with the preoperative control variation (fig. 19). After transorbital leucotomy (group D) there was no significant deviation in the magnitude of the blood pressure or skin resistance response, but the duration increased almost twice, returning to the preoperative value by the third month.

The patients in groups A, B, and C showed slightly increased responses particularly in the magnitude of the fall of the diastolic blood pressure. The drug action of causing vasodilatation is either increased, or the basic vasoconstrictor tonus is lessened. The skin resistance changes were somewhat greater in the dorsum of the hand, except in the first month following thermocoagulation (however the basic palmar skin resistance was high in these 2 cases). In general, the low basic palmar resistance did not show statistically significant deviations from preoperative values. The great change of dorsal skin

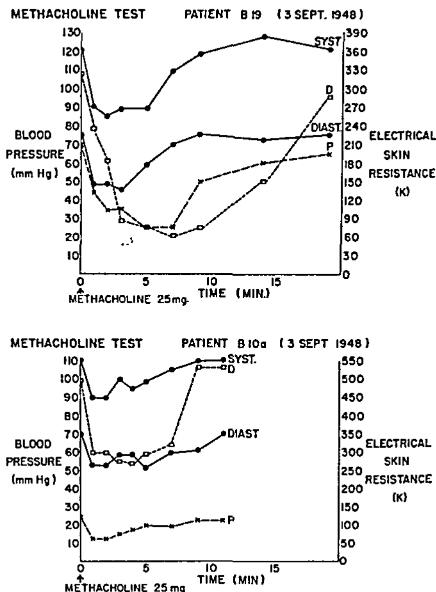


FIG. 18. Methacholine test. The two types of response to acetyl-beta-methylcholine (Methacholine), 25 mg injected subcutaneously. Syst. = systolic blood pressure; Diast. = diastolic blood pressure; D = dorsum of hand skin resistance; P = palmar skin resistance. (Top) The usual pattern of parallel falls of dorsum and palmar skin resistance. (Bottom) "Reversal" of the usual pattern, dorsum skin resistance falling below palmar.

resistance after thalamotomy might be due to the left hemiplegia present postoperatively. Marked autonomic instability of hemiplegic extremities has been noted frequently (Hitzig, 1876; Horsley, 1889; Bucy, '35; and Kennard, '35). The duration of the responses of patients in groups A and B was prolonged postoperatively with a return to normal range by the third month.

The results of the methacholine test suggest hyperreactivity of the parasympathetic system after operative procedures on the frontal lobes and thalamus. This corresponds to the increased carotid sinus reflex

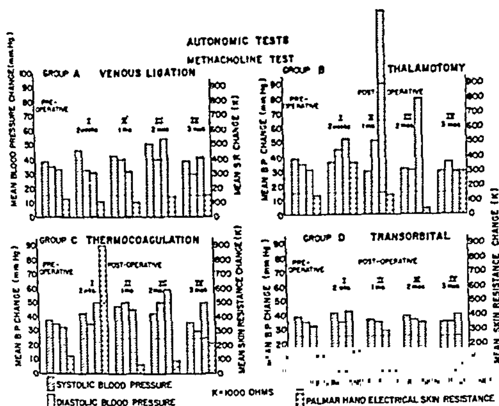


FIG. 19. Magnitude of mean maximal changes in blood pressure and skin resistance after various procedures.

response found after lobotomy by Rinkel and co-workers ('47). These findings, as with the epinephrine test, indicate a possible release of cortical inhibition of both phases of autonomic nervous function. The magnitude of the hyperreaction of parasympathetic response is less than that of the sympathetic. This might be due to the better parasympathetic system stability postulated in schizophrenia (Hoskins, '46; Gellhorn, '42).

Cold Pressor Test

This test was performed according to the method of Hines ('39). The patient was resting in bed for at least 30 minutes prior to the test and baseline blood pressure determined. One arm was placed, then, in ice water (3-5° C) with water level above the wrist, for one minute. Blood pressure was determined on the other arm at 30 seconds, one minute and at minute intervals until control values returned.

Preoperatively, 2 tests were performed on each patient usually on the same day as the epinephrine test. Postoperatively each patient was tested after 2 weeks (groups A, B, C), one week (group D), and at monthly intervals for 3 months. The results of these tests are charted in fig. 20, with regard to the group as a whole preoperatively and the operative groups postoperatively.

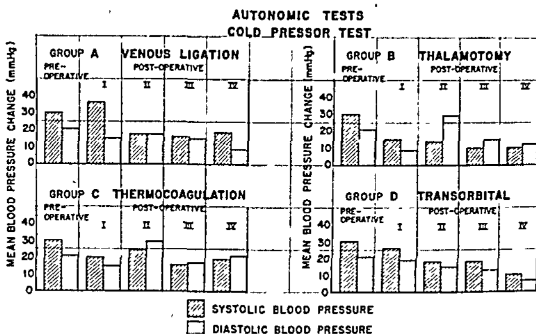


FIG. 20. Responses to the cold pressor test following various operative procedures.

The preoperative average increases of 28 ± 1.2 mm Hg of systolic pressure and 21 ± 1.6 mm Hg diastolic pressure, are slightly above the average response (+22/+15) (Hines, '40; Feldt, and Wenstrand, '42). However, this is regarded as normal hyperreaction. Reider ('38) performed the test on 19 schizophrenic patients and found normal hyperreaction in 8 patients and hyporeaction in 11. Actually, the high values of the present series are probably due to the excessive reaction of 2 of the patients with vasomotor lability (+50/+40). Patient B7 did not show excessive reaction. Also, several of the patients were markedly anxious during the test.

Postoperatively (fig. 20), the average responses of the 4 groups of patients show in general, either no significant change or a diminution of reactivity. This was notable particularly with regard to the systolic pressure, the diastolic response showing occasional slight elevation in the second postoperative month (groups B and C). This response is different from the tendencies toward postoperative autonomic hyperreactivity seen in response to epinephrine and methacholine. With regard to these drugs, the stimulation is directly of autonomic effector organs, while the afferent arc of the cold pressor test is more complex. It is felt that this test is based, in great part, on psychic stimulation particularly that related to pain. White and Gildea ('37) used it as a "standardized emotionally disturbing situation" and noted a tendency toward hyperreaction in neurotic patients, although this was not always constant. It is possible, therefore, that in this series, the psychic reaction of the patients to the test became less, either due to better adjustment to test conditions or to some further blunting of emotional reactivity by the operative procedures. Diminished reactivity to painful stimuli has been noted after frontal lobotomy.

None of the cases receiving transorbital lobotomy showed excessive motor activity, spontaneous or induced, or excessive gastrointestinal, or respiratory responses.

The problem of autonomic responses after lesions of the frontal lobes and thalamus requires much more investigation. The use of schizophrenic patients brings in the factor of the wide variation of psychologic responses characteristic of this group. Further observations with more specific lesions, variable frequency stimulation with recording from autonomic nerves and effector organs, as well as further clinical studies under more constant atmospheric conditions are indicated. It is quite possible that the autonomic hyperreactivity to epinephrine and methacholine noted postoperatively is non-specific since similar responses are seen after head injury, i.e., postconcussion vasomotor instability. Further studies of neurologic patients with parietal, temporal, and occipital lobe lesions are planned in order to define the specificity of the frontal lobes in this respect.

STUDIES OF CARBOHYDRATE METABOLISM. In the present series, carbohydrate metabolism was studied utilizing serial determinations of fasting blood sugar, oral glucose tolerance tests, and insulin tolerance tests. The data were analyzed with regard to possible deviations correlated with the schizophrenic state and for any significant changes following the different operative procedures.

Total lymphocyte counts were determined during the tolerance tests. Recent studies (Dougherty and White, '45; White and Dougherty, '45; Elmadjian and Pincus, '45) have indicated that the number of circulation lymphocytes is related in part to the "alarm reaction" of Selye, as a physiologic adaptative reaction to stress. In normal individuals under severe stress a lymphocytopenia occurs. It is felt that these changes are probably under the control of pituitary-adrenotrophic hormone stimulation of the production of adrenal cortical steroids, particularly the 11-oxysteroid group. These hormones act on lymphatic structures and are also concerned with carbohydrate metabolism, (Long, Katzin, and Fry, '40). A study of total lymphocytes during the glucose and insulin tolerance tests therefore was indicated.

FASTING BLOOD SUGAR. All blood sugar determinations were by the method of Folin-Wu using a photoelectric colorimeter. Although other reducing substances than glucose contribute to this reaction, for the practical purpose of these studies they can be ignored.

During the preoperative control period 69 determinations of fasting blood sugar on the 23 patients gave a range of 55-100 mg per cent with mean at 75.5 $\pm$ 1.7 (SD 8.3). The range of values was within normal limits and indicated that probably all values were truly fasting. The average fast period was 15-16 hours. All patients were on a regular hospital diet which was high in carbohydrate. There was no correlation of the level of fasting blood sugar and the affective state of the patients.

Postoperative determinations were made after 2 weeks and at monthly intervals up to 3 months. The immediate postoperative period of patients in groups A, B, and C was not utilized because of the intravenous therapy given.

Postoperatively, all fasting blood sugar values remained with the limits of the preoperative variation for all individual cases, groups, and in all test periods.

A tendency towards fasting hyperglycemia has been noted after frontal lobe lesions, i.e., topectomy and lobotomy (Heath, Carpenter, Gass, and Weber, '49) but this has not been a consistent phenomenon.

GLUCOSE TOLERANCE TESTS. Glucose tolerance tests were performed twice on each of 23 patients in the preoperative control period and the data for the group as a whole combined (fig. 21). For each test, 50 gms of glucose were administered orally, according to the recommendations of Peters and Van Slyke ('46, pp. 167-184). Samples were taken at fasting, then 30, 60, 90, 120, and 180 minutes after glucose administration. Lymphocyte counts were made at fasting, one and 2 hours. Peak blood sugar rises occurred at 30 or 60 minutes (only infrequently at 90 minutes) and varied from 20-111 mg per cent

PREOPERATIVE CONTROL PERIOD DATA : GLUCOSE AND INSULIN TOLERANCE TESTS

GLUCOSE TOLERANCE TESTS (46 TESTS ON 23 PATIENTS)

TIME (MIN)	BLOOD SUGAR (mg %)		LEUCOCYTES (Total)		LYMPHOCYTES (Total)		REMARKS
	M AND σM	SD	M AND σM	SD	M AND σM	SD	
0	73.5±1.7	8.3	8800±360	1900	3500±200	1000	DOSE 50 Grams p.o.
30	116.0±2.8	14.1					
60	118.0±3.7	18.4	8900±330	1600	3500±100	500	
90	108.0±3.3	16.3					
120	99.0±2.3	12.3	8600±430	2100	3500±190	900	
180	81.0±1.2	6.2					

INSULIN TOLERANCE TESTS (45 TESTS ON 23 PATIENTS)

TIME (MIN)	BLOOD SUGAR (mg %)		LEUCOCYTES (Total)		LYMPHOCYTES (Total)		REMARKS
	M AND σM	SD	M AND σM	SD	M AND σM	SD	
0	71.5±2.4	12.0	8800±400	2000	3400±140	700	DOSE 0.1 Unit/Kg IV
30	37.5±1.9	9.3	9600±500	2400	3900±230	1100	
60	53.0±2.1	10.5					
90	66.0±2.0	10.0	9000±300	1600	3600±180	900	
120	75.0±1.4	6.8					Epi 0.01 mg/Kg subcut after 120 min.
180	91.0±1.6	7.9					

M = MEAN, σM = STANDARD ERROR OF MEAN; SD = STANDARD DEVIATION

FIG. 21. Combined data from 2 preoperative tests on 23 patients.

(average 42.5 mg per cent.) All curves are regarded to be within normal limits. There was neither delayed rise nor persistent hyperglycemia. The total lymphocyte count remained within normal limits

of variation during all tests. Minor elevations and depressions occurred but were not significant statistically. The variation at fasting level was 3510 ± 207 (SD 1037) and at one hour, 3456 ± 97 (SD 487).

Previous investigators have studied glucose tolerance curves of schizophrenic patients (McFarland and Goldstein, '38; Robinson, G. W. and Shelton, '40; Eaton and Muntz, '47). Great variability occurs: normal, no characteristic response, prolonged hyperglycemia, or flat curves have been found. H. I. Freeman, Looney, and Hoskins ('42) determined the "spontaneous" variability of oral glucose tolerance curves, concluded that considerable variation exists in the same individual on different days and that only gross trends are significant. H. I. Freeman and Elmadjian ('47) studied the relationship between blood sugar and lymphocyte levels in normal and schizophrenic subjects using the Exton-Rose test. They found the predominant normal reaction to be a lymphocytopenia associated with the hyperglycemic

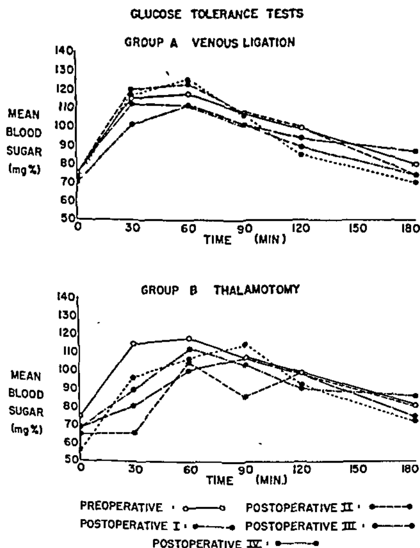


FIG. 22. Glucose tolerance test results following venous ligation and thalamotomy.

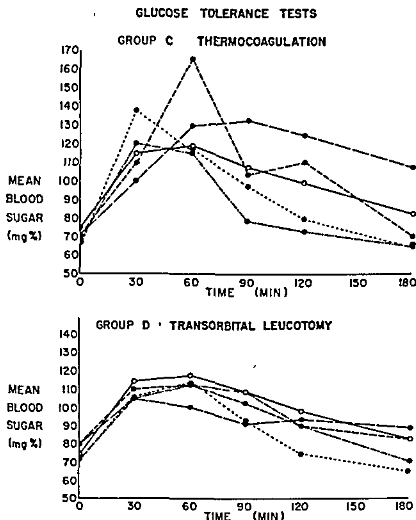


FIG. 23. Glucose tolerance test results following thermocoagulation and transorbital leucotomy.

response. In most schizophrenic patients, particularly those with the least affect, the lymphocytopenic response was minimal. The group of patients in this present series was characterized by minimal affective display and this would correlate with the absence of significant lymphocytic change. This might indicate less active adrenocortical responses in these patients and further studies are planned to evaluate these factors.

The postoperative tests were carried out in the standard test periods. The first test was at 12-14 days for groups A, B, and C, and 4-8 days postoperatively for group D. The composite curves for each group are shown in figures 22 and 23. The tests on patients in groups A, B, and D were within normal limits of variation for each time period. In no case did excessive rise or delayed fall occur to a significant degree. The tests of the 2 patients in group C showed a tendency towards prolonged hyperglycemic response after 2 weeks and higher peak rise after the first month.

The total lymphocyte count remained within the previous control limits of variation during all tests.

Transient alterations in glucose tolerance have been noted commonly in association with cerebral lesions. Following topectomy (Heath, et al., '49) significant increase in the peak sugar response and/or a delayed fall occurred during the first postoperative month, especially at the first week and particularly when the granular areas (9, 10, 24, 44, and 47) were ablated. These changes persisted in moderate degree through the second week. Although the present series does not include determinations in the first postoperative week (with the exception of the transorbital group), due to necessity of intravenous therapy during this period, the tests of the second week following transorbital leucotomy did not indicate any significant hyperglycemic trend. However, this was noted in the 2 cases of thermocoagulation which apparently directly involved areas 9 and 10.

The absence of any significant change in lymphocytes is correlated with a general absence of notable change in the psychiatric picture with regard to affective response.

INSULIN TOLERANCE TESTS. Insulin tolerance tests were performed 45 times on the 23 patients during the preoperative control period and the data for the group as a whole have been combined and analyzed (fig. 21).

Method. For each test, the fasting blood sugar sample was taken and insulin administered intravenously at dosage 0.1 unit/kg body weight according to the method of Fraser, Albright, and Smith ('41). Blood samples were taken at 30, 60, 90, 120 minutes. After the 2-hour sample, epinephrine, 0.01 mg/kg body weight was given subcutaneously and a blood sample drawn one hour later.

The composite preoperative curve (fig. 21) indicates that the group of patients as a whole had a normal blood sugar response to insulin, i.e., a 48 per cent fall, from mean value of 71.5 $\pm$ 2.4 to 37.5 $\pm$ 1.9 mg per cent with return to 75 mg per cent at 2 hours. Fraser, Albright, and Smith ('41) indicate that normally a 40-50 per cent fall occurs by 30 minutes, with a gradual rise to control basic value by 1-1/2 to 2 hours. In no case was there evidence of insulin resistance or hypoglycemia unresponsiveness.

The response to epinephrine, a mean rise of 16 mg per cent is within the lower limit of normal variation.

Previous studies of insulin tolerance in schizophrenic patients have shown conflicting results. Horvath and Friedman ('41) found a delay in hypoglycemic effect and subsequent recovery. Meduna, Gerty, and Urse ('42) found an anti-insulin factor in the blood of schizophrenic patients. This was not confirmed by Goldner and Ricketts ('42). Gellhorn, Feldman, and Allen ('42) found no difference in the insulin content of the blood of normal or psychotic patients in a quiet state but

the blood insulin of psychotics when excited, increased to an hypoglycemic effect never seen in normal cases. H. I. Freeman, Looney, Hoskins, and Dyer ('43) performed insulin tolerance tests on 32 male schizophrenic patients and 20 normal controls using the method of Fraser, Albright, and Smith. There was a suggestion of insulin resistance in the patients as compared with the controls but all of the curves actually fell within the limits of normal variation. There was no relation to age or subtype of psychosis.

Total lymphocytes were determined during the course of the insulin tolerance tests, the counts being made at 0, 30 minutes, and 1-1/2 hours. No significant deviations from the normal range of variation occurred in the preoperative control group as a whole or in individual cases (fig. 21), the variation at fasting level being 3418 ± 226

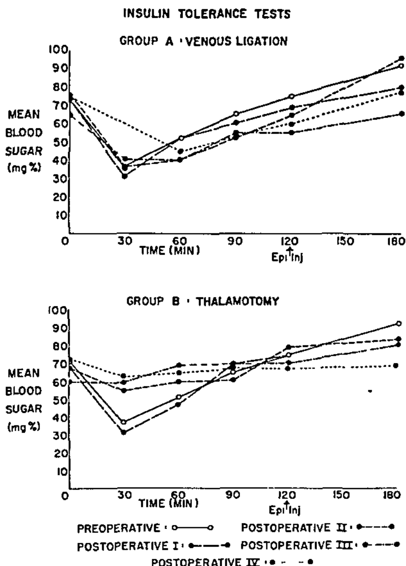


FIG. 24. Insulin tolerance test results following venous ligation and thalamotomy.

(SD 1128). There was no correlation with affective state and a wide scattering of values was noted.

The postoperative determinations were performed the day following the glucose tolerance tests, and are charted in figures 24 and 25.

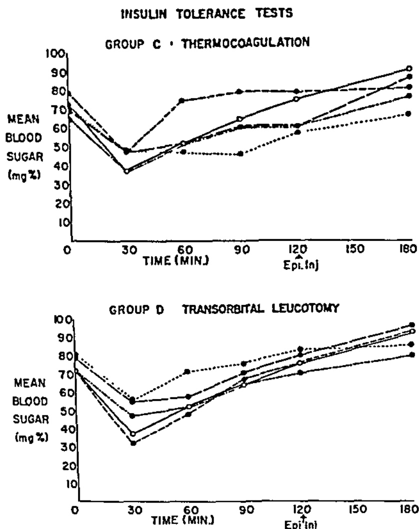


FIG. 25. Insulin tolerance test results following thermocoagulation and transorbital leucotomy.

The curves of groups A, C, and D show no significant variation from the normal range. The 2 patients receiving thalamotomy had a tendency to postoperative insulin resistance persisting to the third month. The total lymphocyte counts during the postoperative tests showed no significant trends or variations from the preoperative values. The suggestive changes in blood sugar responses after thalamotomy and thermocoagulation should be confirmed on a larger series of cases before proper evaluation can be attempted.

SUMMARY & CONCLUSIONS

1. The medical section of the project surveyed the general medical condition of the patients, obtained and analyzed clinical laboratory findings, especially hematological, and studied carbohydrate metabolism and autonomic nervous system stability by means of special tests. Twenty-three patients were studied preoperatively and 22 postoperatively (n.b. one postoperative death). Preoperative control observations were obtained at regular intervals during the 2-month period prior to operation and adequate, accurate baseline control data were obtained on all cases. The postoperative studies were performed at frequent periods during the first month and at monthly intervals thereafter for 4 months. The data were grouped into the 4 operative categories: venous ligation, thalamotomy, thermocoagulation, and transorbital lobotomy.

2. All patients were in good physical condition prior to operation. There was one postoperative death, patient B4, following venous ligation (due to intracerebral hemorrhage), and 2 wound infections, in patients B7 and B10A, following venous ligation. All other patients were in good medical condition after the initial postoperative shock period (particularly severe after thalamotomy). Twenty-five blood transfusions were given to the patients receiving venous ligation, thermocoagulation, and thalamotomy during the initial postoperative period.

3. No significant changes in menstrual cycles or weight occurred postoperatively.

4. Hematological: Preoperatively, normal variation was found in all cases with regard to hemoglobin, erythrocytes, leucocytes and lymphocytes, reticulocytes, hematocrit, and erythrocyte sedimentation rate. Postoperatively, after venous ligation, thalamotomy, and thermocoagulation, moderate falls occurred in hemoglobin, erythrocytes, reticulocytes, and hematocrit and no change or slight rises in leucocytes and lymphocytes during the first 3 weeks. A gradual rise to normal control values occurred by the second or third month. The changes were of similar magnitude in all 3 groups. Following transorbital lobotomy no significant deviations occurred in those constituents. The sedimentation rate rose to high values during the first postoperative week after venous ligation, thalamotomy, and thermocoagulation with gradual return to the normal preoperative range. Only 2 of the 7 patients showed slight elevations of sedimentation rate after transorbital leucotomy.

5. Blood pressure: Preoperatively, blood pressures were within the normal range for all cases except 3 with labile pressures and evidence of vasomotor instability (B2, B7, B8). Following venous ligation, thalamotomy and thermocoagulation, minor depressions and fluctuations persisted throughout the first postoperative month with return to normal by the third month. No changes occurred after transorbital lobotomy. One patient (B7) showed persistent hypertension for 2 months after venous ligation.

Circulation time: Normal variations occurred preoperatively and no significant deviations occurred postoperatively except after thalamotomy when the patients were bedridden, hemiplegic, and probably had a slow reaction time.

6. Autonomic tests: Autonomic nervous system responsiveness was evaluated by measuring the response of blood pressure to epinephrine (sympathomimetic), methacholine (parasympathomimetic), and cold pressor test (complex response to psychic and vasoconstrictor stimuli). The duration of the response in all tests and the electrical skin resistance, with the methacholine test, also were measured. All preoperative responses were within normal limits except for the 3 patients with labile vasomotor responses. There was no correlation with the psychiatric status. Postoperatively, there was a tendency, in all cases, towards hyperreaction to the direct autonomic effector stimulus of epinephrine and methacholine, especially epinephrine. This occurred in the first 2 months postoperatively, and gradually returned to the normal degree of response. These results suggest a diminution of cerebral inhibition of autonomic function after operative procedures on the frontal lobes and the thalamus. The postoperative cold pressor tests showed a tendency toward diminution of response to this stimulus, which is regarded as predominantly psychic. Definitive correlation of these results with postoperative psychiatric change was not possible.

7. Studies of carbohydrate metabolism: The fasting blood sugar was within normal limits preoperatively in all cases and showed no significant deviations after any of the operative procedures. Glucose tolerance tests showed normal variation preoperatively, and postoperatively after all procedures except thermocoagulation. The latter cases showed a tendency to prolonged hyperglycemia after 2 weeks and a high peak rise after the first month. The total lymphocyte counts remained unchanged during the pre- and postoperative tests. The normal degree of lymphocytopenic response never occurred. Insulin tolerance tests showed normal variation preoperatively and postoperatively after all procedures except thalamotomy. The latter cases showed a tendency towards insulin resistance. The total lymphocyte counts remained within normal degrees of variation during the pre- and postoperative tests. The disturbances in carbohydrate metabolism noted after thalamotomy and thermocoagulation require study on a larger series of cases.

The cooperation and technical assistance of the laboratory staff[5] at the Greystone Park State Hospital are acknowledged and greatly appreciated.

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5. Ralph Benitez, Malcolm Allen, Cora Swackhammer, Laura Kune, Louise Gaddis, and Frederick Kovaler.

Chapter 5

NEUROLOGY

William Caveness and H. Houston Merritt

At the outset, the neurologic discipline assumed the responsibility of a general neurologic survey before and after the operative period. This survey followed the outline of the examination form used at the Neurological Institute of New York. Because of the overlap of disciplines, gross but not definitive examinations were made of visual acuity, fields, auditory acuity, and vestibular function. On the other hand, more than usual attention was paid to two point discrimination and vibratory sense. A supplementary examination of aphasia was performed.

The incidence of incontinence and convulsive seizures was recorded. Management of the latter was a joint responsibility of this and the surgical disciplines.

Thirty-two patients were examined. Of these, 26 received operative procedures: 12, venous ligation, B1, B2, B3, B4, B5, B6, B7, B8, B9, B10A, B11, B12; 2, thalamotomy, B13, B14; 2, thermocoagulation, B15, B16; 9, transorbital lobotomy, B17, B18, B19, B20, B21, B22A, B23, B28, A10; and one, topectomy, A8. Six patients were used as controls, B10, B22, B24, B25, B26, B27.

The original plan included 2 complete examinations on each patient prior to the operative period and successive examinations in the postoperative period until the neurologic signs and symptoms were again stabilized. The time interval between the operation and the final examinations varied between 3 and 4 months. It was the rare patient whose attention and cooperation permitted a complete survey at one session. In the main, the examinations were done piecemeal with the equivalent of 2 full appraisals before and 3 after the operative period.

Reliable participation in all phases of the examination in the preoperative period was obtained in 24 patients: B2, B3, B4, B5, B6, B7, B8, B9, B10A, B11, B12, B13, B15, B20, B21, B22A, B23, B28, A8, B10, B22, B25, B26, B27. Of these, reliable participation in all phases of the examination in the postoperative period was obtained in 19 patients: B3, B5, B6, B7, B8, B10A, B11, B12, B13, B15, B20, B21, B22A, B23, B28, A8, B10, B25, B27. The failure of the 5, who participated in the complete examination in the preoperative, but not the postoperative period, is accounted for by one death, B4, 2 with imperfect estimations

of vibratory time, B2 and B9, one who categorically refused, B22 control, and one who was transferred, B26, a control.

Conversely, 2 patients, A10, B24 control, in whom it was not possible to test vibratory and two point discrimination prior to the operative period, gave satisfactory performance in the follow-up examinations.

Six patients, B1, B14, B16, B17, B18, B19, gave only fair performances in all trials. Postoperatively they were somewhat poorer than preoperatively. In none of these was adequate testing of vibration and two point discrimination possible.

With the above in mind, the following report gives all of the changes in the neurologic examination which persisted up to the time of the final examinations, 3 to 4 months following operation.

1. STATE OF CONSCIOUSNESS. With the exception of the single patient who died, there was no significant permanent alteration in state of consciousness.

2. MENINGEAL IRRITATION. There was no evidence of meningeal irritation in the preoperative period and in the stabilized postoperative period.

3. CRANIAL NERVES. There was no significant change in the examination of cranial nerves I, II, V, VIII, XI, and XII in any of the patients.

III, IV, VI. In 3 patients, B7, B23, A10, there was inequality in size of pupils. (In 4 patients the pupils were unequal both before and after operation, B2, B3, B20, B28.) In 3 patients, there was an impairment in convergence, B9, B12, B14.

VII. In 2 patients there was a facial weakness, both left: one moderate, one slight, B13, B14.

IX, X. There was no impairment in phonation or deglutition. In one patient, the pharyngeal reflex was diminished, B12. (Five cases showed a diminished pharyngeal reflex both pre- and postoperatively, B5, B6, B8, B17, B25 control.)

4. MOTOR SYSTEM:

a. Gait. No significant alteration.

b. Involuntary Movements. In 6 patients there was a fine tremor in the outstretched hands, B3, B9, B13, B15, B28, A8. In two, B28, A8, there was also a prominent tongue tremor.

c. Strength and Coordination. There was no significant permanent alteration in the strength or coordination of the muscles of the trunk or extremities.

d. Reflexes. There were minor variations in reflex response. In 4 patients there was a decrease in the activity of the tendon reflexes, B1, B2, B17, B10; one being a control, B10. In 2, there was an increase,

B11, B27, one of these being a control, B27. In 3 patients the abd inal reflexes were lost, B8, B10A, B22A.

5. SENSORY SYSTEM:

a. Touch. Intact in all instances.

b. Pain. No alteration in ability to distinguish sharp from was noted. Achilles tendon sensitivity was diminished in 2 patie B6, B12. (It was diminished in both pre- and postoperative perio 6 patients, B8, B13, B14, B16, B17, and B27 control.)

c. Temperature. No significant alteration was noted.

d. Tests. Muscle tendon movement, stereognosis, point local tion, palm writing, and body orientation showed no significant al ation.

e. Vibration Sense. Present in all patients in each examinat In 20 patients, B3, B5, B6, B7, B8, B10A, B11, B12, B13, B15, B20, B21, B22A, B23, B28, B10, B24, B25, B27 (4 of these were c trols, B10, B24, B25, B27), it was possible to obtain an approxin quantitative value for this function before and after the opera period.[6] The mean value for the wrist was 26 seconds; the knee seconds; the ankle, 27 seconds.

In 13 patients, B3, B5, B6, B7, B8, B10A, B13, B15, B20, I B22A, B24, B25, there was a 20 per cent increase in time in the p operative period. Two of these, B24 and B25, were controls.

In 4 patients, B12, B23, B28, B10, the results were similar in l periods. One of these, B10, was a control.

In 2 patients, A8, B27, there was a 20 per cent diminution in ti One of these, B27, was a control.

f. A quantitative estimation of two point discrimination was p sible in 21 patients, B2, B3, B5, B6, B7, B8, B9, B10A, B11, I B13, B15, A8, B20, B21, B22A, B23, B28, B10. B25, B27. Th were controls, B10, B25, B27.[7]

The results showed little dissimilarity from case to case betw the examinations in the pre- and postoperative periods. The aver for the group was 7.3 mm for the thenar eminence, 2.7 mm for index finger, and 2.9 mm for the middle finger.

6. APHASIA SUPPLEMENT. A supplementary examination for ap sia was performed on all the patients. This was an attempt to t

6. Technique: A tuning fork of 128 frequency was set in maximum vibration placed respectively on the right and left styloid process of the radius, patellar and ternal malleolus of the tibia. Time was recorded from the activation of the inst ment to the reported absence of vibratory sensation.

7. Technique: Stroking with one or both points of a pair of dividers, the the eminence, the palmar surface of the terminal phalanx of the index and third finger

receptive and expressive functions. For this the appended form was used (Table 4). Postoperative testing began approximately 10 days after the surgical procedure and continued until stabilization was evident. After many minor and major transitory changes, the following patients showed relatively stabilized alterations.

In 7 patients there was a deterioration in handwriting, B1, B3, B9, B13, B14, B18, B21. In 4 there was a paucity in composition, B3, B13, B14, B27. In 2 patients there was an impairment in the ability to perform the serial sevens test, B13, B18. In one, B11, there was an improvement in the performance of this test. As will be noted, in one patient, B13, there was an impairment in many areas. In evaluating

Table 4

FORM FOR SUPPLEMENTARY EXAMINATION
FOR APHASIA

Handedness:

Receptive

1. Spoken word understanding as judged from correct response to simple commands

2. Written word understanding: Sweet, sour, salt, bitter, Babies Hospital

3. Name of objects: Shoe, tie, watch, pencil, eraser, stem of watch, crystal of watch. Colors

4. Tactile interpretation. Dime, quarter, pencil and ruler. Localization. Palm writing

Expressive

5. Gross defect of speech production.
Test phrases: Medical electricity, Methodist Episcopal, around the rugged rock, the ragged rascal ran

6. 1-20, A-Z

7. Verbal description of canary

8. Serial sevens

9. Written name, date, description of house.
From dictation: The beds here are white

10. Demonstration of lighting cigarette and drinking from glass

11. See body orientation under sensory examination. Patient asked to place right thumb on nose and left index finger on right ear

this case, sight should not be lost of his deteriorated psychiatric state. At the present time, he is capable of little more than "word salad."

One patient, B6, presented a unique problem in evaluation in the preoperative period. A note from this period states: "Patient sits with eyes everted. Mouth and jaws twitch when attempting to speak. He talks in a soft voice, almost a whisper. Seems to have difficulty in getting words out, but finally comes out with right words. His speech, though soft, has an explosive type of production. When not answering direct questions, talks much more easily, less grimacing, freer flow of words. When asked to write a brief description of a house, his brow furrows, his hands tremble, and his jaws work. After some time he writes. Test phrases were said without error." Postoperatively there was a little more amplitude and little less hesitancy. It is thought that his speech difficulty is psychologic in origin.

One patient, A10, presented an interesting transient phenomenon that is indicated in the accompanying illustrations. Preoperative test-

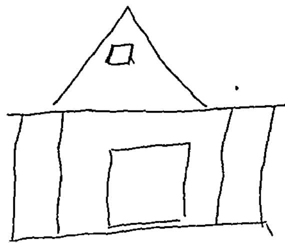


FIG. 26. See page 89 of text for explanation.

ing, 10/16/48, showed good receptive function and reasonably good expressive function. There was no gross defect in speech production. Counting from 1-20 was easily accomplished. In saying the letters of the alphabet, G H were repeated and the patient stopped at Y. In the verbal description of a canary he said: "A nice little bird, give it attention and it does its work, gives a few tunes, nice little bird." Serial sevens were done without error. His name, date, description, and dictation were moderately well performed (fig.26).

On 10/28/48 a transorbital lobotomy was performed on this patient. On the following day he did not speak. On the second day, he spoke only when addressed and then in monosyllables. These were not always clear. With apparent improvement, he was next tested on 11/10/48, 13 days following operation. In the receptive functions he failed to name matches, an ashtray, a ruler, and a button. The last 3 were called fountain pens. A watch was called a thermometer. A key was called a lavalier. In the expressive functions, he omitted Ragged from the familiar test phrase. In attempting to count to 20, after reaching 15, he stated, "After that I can't get it." In saying the letters of the alphabet, he proceeded as far as L with the omission of G and

2 [redacted]



FIG. 27. See page 90 of text for explanation.

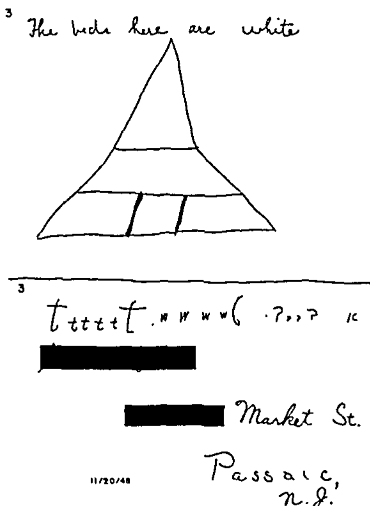


FIG. 28. See page 91 of text for explanation.

stated, "After that I can't guess." In the verbal description of a canary, he said: "A canary is like a nice mocking bird." In attempting serial sevens, he gave 93, 86, 80, 73, 80, and was then unable to proceed. When asked to write his name and date, he began at the right hand margin of the page and wrote his name in printed letters from right to left inserting an additional letter in his first name. This was followed again from right to left by the printed letters M A S K E T. When prompted to write the date, he then began at the left hand side of the page and printed the word d a t e. He was then asked to describe a house. Again he wrote the word d a t e. When reminded of his purpose, he started at the right side of the page and then while mumbling something that sounded like "about," he wrote from right to left ABOUTS and then skipping a space, W. He was then asked to write from dictation, "The beds here are white." This he accomplished from left to right beginning in printing and ending in script (fig. 27).

On 11/20/48, 23 days after the operation, the patient made only one error in naming objects, calling the stem of a watch a wristlet. With

hesitation and apparent effort, he was able to count to 20 and repeat the alphabet, but with X and W reversed in order. His description of a canary was, "Canary is nice yellow bird." Serial sevens consisted of 99, 98, 97, 96, 95, a pause, 93, 86. When asked to write his name and the date, he wrote 5 repetitious characters from right to left that were not immediately recognizable. When prompted to try again to write his name and the date, he wrote from left to right—his name, Market Street, Passaic, New Jersey (the address of his childhood home). When asked to describe a house, he drew a picture, simpler in design than his preoperative drawing. When a similar request had been made from dictation, he correctly wrote in script, "The beds here are white" (fig. 28).

On 12/3/48, 36 days after operation, receptive functions were intact. Expressive functions as tested were much improved. A canary was said to be "like a nice swallow but of course a canary is better than a swallow." Serial sevens were performed without error. When asked to write his name and date, he wrote his name in the usual fashion and a date, although a wrong one. The description of a house was given as, "The description of a four family house is just like a bear having small little bears and what takes place in the house is everybodys business." Dictation was correctly accepted and performed (fig. 29).

4 [redacted]



October 1 1948

The description of a four family house is just like a bear having small little bears and what takes place in the house is everybodys business



The beds here are white

12/3/48

FIG. 29. See this page of text for explanation.

On 12/13 and 12/21/48, creditable response to all phases of the examination was given (fig. 30).

It had been known that this patient was left-handed as a child, and was forced to use his right hand for the usual functions in kindergarten at 5 years of age. To the best knowledge of the family, he has

5 [redacted] December 12, 1948

A nice small house has a nice lay out of windows and has a nice small garage The windows in general number about fifteen. and they are very airy and present a very nice cool comfortable appear-ance

The kitchen has a nice laundry and a nice washroom.

The beds here are white.

12/13/48

FIG. 30. See page 91 of text for explanation.

never reverted to his left hand for writing. However, at the present time when asked to do so, he can write with his left hand in a legible fashion. Inquiry into further details of his childhood disclose that while this boy was started in English school at the age of 5, he entered Hebrew school at the age of 6, and for the ensuing 9 years attended both schools simultaneously. At the Hebrew school he was an outstanding scholar of which he and his family were very proud. It will be recalled that Hebrew is written from right to left. Upon asking the patient to write his name in Hebrew, 12/18/48, this was done from right to left with a combination of Hebraic and English characters.

6

[redacted]

[illegible]

12/18/48

FIG. 31. See page 93 of text for explanation.

Immediately after this performance, he spontaneously wrote 5 characters from right to left, 3 of which are recognizable as the first 3 letters in the Hebraic alphabet. (A copy of the latter is appended beneath the patient's specimen.) (Fig. 31.) The first 2 of these are quite similar to the first 2 characters that he wrote repetitiously from right to left during the examination on 11/20/48.

ANALYSIS OF PERSISTING NEUROLOGIC ALTERATION ACCORDING TO TYPE OF OPERATIVE PROCEDURE

VENOUS LIGATION (12 cases): Cranial Nerves: Four cases, B5, B7, B9, B12, showed some postoperative modification. B7 had unequal pupils, B9 and B12 had difficulty in convergence, B12 had diminution in pharyngeal reflex. B5 and B9 had displacement of the uvula.

Motor System: Four, B3, B8, B9, B10A, showed some postoperative change. B3 and B9 had a fine tremor in the outstretched hands.

Reflexes: B8 and B10A had absent abdominal reflexes.

Sensory System: Achilles tendon sensitivity. Two, B6 and B12, showed diminution following operation.

Vibration Sense: In the preoperative period, quantitative estimation was possible in 11 cases; in the postoperative period, 8 cases: B2, B3, B4, B5, B6, B7, B8, B9, B10A, B11, B12; and B3, B5, B6, B7, B8, B10A, B11, B12, respectively.

Of the 8 that participated in both phases, 7 showed an increased vibratory time, B3, B5, B6, B7, B8, B10A, B11. One showed little change, B12.

Two Point Discrimination: In the preoperative period, quantitative estimation was possible in 11 cases: in the postoperative period, 10 cases: B2, B3, B4, B5, B6, B7, B8, B9, B10A, B11, B12; and B2, B3, B5, B6, B7, B8, B10A, B11, B12 respectively. (B4 died.) Of the 10 that participated in both phases, there was remarkably little difference in any of the performances with a minor exception in B8, who showed less reliability on repetitious tests in the postoperative period.

Speech: Three, B1, B3, B9, showed deterioration in handwriting. One of these, B3, showed diminution in composition.

THALAMOTOMY (2 cases): Cranial Nerves: B14 showed difficulty in convergence.

Motor System: B13 showed a fine tremor in the outstretched hands. B13 and B14 showed a left facial weakness, moderate and slight, respectively.

Reflexes: No alteration.

Sensory System: Achilles tendon sensitivity. No alteration.

Vibration Sense: One, B13, participated in both phases, showing an increased vibratory time in the postoperative period. (B14 gave a quantitative estimate only in the postoperative phase.)

Two Point Discrimination: B13 and B14 showed reasonably good discrimination in the preoperative phase, but B14 failed to discriminate in the left index and middle finger in the postoperative period.

Speech: No alteration.

THERMOCOAGULATION (2 cases): Cranial Nerves: No alteration.

Motor System: One, B15, showed a fine tremor in the outstretched hands.

Reflexes: No alteration.

Sensory System: Achilles tendon sensitivity. No alteration.

Vibration Sense: In the preoperative period, quantitative estimation was possible in 2 of the cases, B15, B16. In the postoperative period, this was possible in one, B 15, who showed an increased vibratory time.

Two Point Discrimination: In the preoperative period, quantitative estimation was possible in one case, B15. The same was true in the postoperative period. No significant change was noted.

Speech: No alteration.

TRANSORBITAL (9 cases): Cranial Nerves: Two, B23, A10, showed inequality in pupils.

Motor System: One, B28, had a fine tremor in the outstretched hands. One, B22A, had absent abdominal reflexes.

Reflexes: No alteration.

Sensory System: Achilles tendon sensitivity. No alteration.

Vibration Sense: In the preoperative and postoperative periods, a quantitative estimation was possible in 5, B20, B21, B22A, B23, B28. Three showed an increase in vibratory time, 2 showed no change.
One case, A10, gave no preoperative estimation, but produced a satisfactory demonstration in the postoperative examinations.

Two Point Discrimination: In the preoperative period, 5 gave good estimations, B20, B21, B22A, B23, B28. The same 5 turned in similar performances in the postoperative period. In addition, one, A10, who failed to give a satisfactory performance in the preoperative period, did very well in the postoperative phase.

Speech: Two, B18, B21, showed deterioration in handwriting. One of these showed impairment in serial sevens.

TOPECTOMY (one case) A8: Cranial Nerves. No alteration.

Motor System: Tremor in the outstretched hands was noted in the postoperative period.

Reflexes: No alteration.

Sensory System: Achilles tendon sensitivity. No alteration.

Vibration Sense and Two Point Discrimination. This case did well in all examinations, showing a moderate diminution in vibratory time in the postoperative phase.

Speech: No alteration.

CONTROLS (6 cases): Cranial Nerves. No alteration.

Motor System: No alteration.

Reflexes: No alteration.

Sensory System: Achilles tendon sensitivity. No alteration.

Vibration Sense: Six gave satisfactory preoperative response, B10, B22, B24, B25, B26, B27. Four gave satisfactory response in the postoperative period, B10, B24, B25, B27. Two were unavailable, B22, B26. Of the 4 that participated in both phases, 2 showed increased vibratory time, B24, B25; one showed no change, B10, and one showed moderate diminution, B27.

Two Point Discrimination: Five gave satisfactory preoperative response, B10, B22, B25, B26, B27. Three of these gave a similar response in the postoperative period, B10, B25, B27. Two were unavailable in the latter period, B22, B26. One who gave an unsatisfactory response in the preoperative period, gave an adequate response in the postoperative period, B24.

Speech: One showed diminution in composition, B27.

INCIDENCE OF INCONTINENCE

Six patients, B1, B2, B3, B4, B13, B14, were incontinent from 9 to 16 days, apparently as the direct consequence of the operative procedures. Four of these had venous ligation. Two had thalamotomies. Indirectly related to the procedures were the following: 2, B9 and B10A, were incontinent only during short intervals, 2 days of fever and semi-coma respectively. Two, B6 and B12, were incontinent only with seizures. One, A8, was incontinent for 9 days during which time the element of indifference was hard to discount.

Prior to the operative procedures, one of the study group, A10, was known to be occasionally incontinent. Following operation he was again without adequate control.

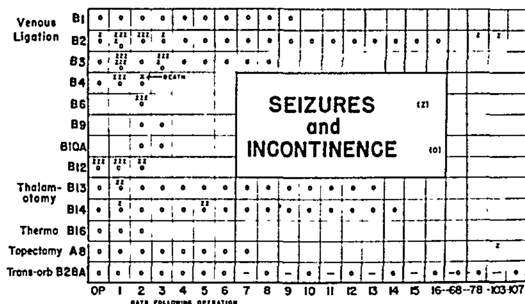


FIG. 32. Incidence of convulsive seizures and incontinence following various operative procedures.

INCIDENCE OF CONVULSIVE SEIZURES

Only one patient, A8, was known to have convulsive seizures prior to the present operative period. He developed focal seizures following surgery in the previous topectomy study. Following his second operation, and extension of his previous topectomy, 10/20/48, he was free of seizures for 2 months. On 12/27/48 and 1/31/49 he had single seizures.

Seven patients of the present study, B2, B3, B4, B6, B12, B13, B14, had seizures in the immediate postoperative period. These generally occurred within the first 24 hours and persisted for from one to 4 days. One died, B4. Five have remained seizure free since this period, B3, B6, B12, B13, B14. One, B2, after a free interval of 3 months had a single seizure 1/10/49. None have had anticonvulsant medication since the immediate postoperative period. Of these 7 patients, 5 had venous ligation, 2 had thalamotomies.

NOTES ON INCONTINENCE

B1—operation 10/4/48. Venous Ligation.
Incontinent of urine from this date up until 10/13/48. Involuntary of feces following enemas.

B2—operation 10/4/48. Venous Ligation.
Incontinent from this date until 10/20/48. Involuntary of feces following enemas.

B3—operation 10/5/48. Venous Ligation.
Incontinent from this date until 10/13/48. Involuntary of feces following enemas.

B4—operation 10/5/48. Venous Ligation.
Incontinent of urine until death 10/7/48.

B6—operation 10/6/48. Venous Ligation.
Incontinent only following seizures.

B9—operation 10/8/48. Venous Ligation.
Incontinent only during period of high temperature, starting 10/10/48, ending 10/11/48.

B10A—operation 10/8/48. Venous Ligation.
Incontinent only during comatose state, starting 10/10/48, ending 10/11/48.

B12—operation 10/12/48. Venous Ligation.
Incontinent only following seizures.

B13—operation 10/13/48. Thalamotomy.
Incontinent from this date until 10/26/48. Involuntary of feces following enemas.

B14—operation 10/14/48. Thalamatomy.
Incontinent from this date until 10/29/48. Involuntary of feces following enemas.

B16—operation 10/18/48. Thermocoagulation.
Incontinent from this date until 10/20/48.

A8—operation 10/21/48. Topectomy.
Incontinent from this date until 10/30/48.

A10—operation 10/28/48. Transorbital Lobotomy.
This patient was incontinent before operation. This occurred in cycles. After operation, patient was incontinent of urine and involuntary of feces following enemas. As the postoperative confusion cleared, the incontinence occurred less often. At the end of 3 months, its incidence had again increased.

NOTES ON CONVULSIVE SEIZURES

B2—operation 10/4/48. Venous Ligation.
Returned from operating room at 8 p.m.

10/4/48

1. 9:55 p.m. Generalized seizure lasting 2 minutes. Started with right arm. Eyes deviating first to right side, then to left side. About one minute for each side.

10/5/48

2. 8:20 a.m. Seizure began with frothing from the mouth followed by generalized twitching, lasting one minute.
Phenobarbital sodium 1 gr at 8:45 a.m.
3. 12:00 noon. Twitching of legs and body only lasting 30 seconds.
Phenobarbital sodium 1 gr 12 noon
4. 2:45 p.m. Twitching of right arm becoming generalized, lasting for 30 seconds.
5. 5:45 p.m. Mild twitching involving entire body for one minute.
Phenobarbital sodium 2 gr at 6 p.m.

10/6/48

6. 12:30 a.m. Twitching of facial muscles only, lasting one minute. (Masticatory seizure?)
Phenobarbital sodium 2 gr at 12:45 a.m.
7. 3:00 a.m. Twitching of facial muscles only, lasting for a period of 3 minutes.
8. 9:30 a.m. Generalized body twitching, lasting 2 minutes.
Phenobarbital sodium 2 gr at 9:45 a.m.

10/7/48

9. 9:05 a.m. Generalized convulsion, lasting one minute. Eyes deviating to the right side. Started from right arm.
Phenobarbital sodium 2 gr at 10:00 a.m.

This patient had a series of 9 convulsions lasting over a period of 3 days, during which time she received 10 grains of Phenobarbital sodium. Note: Seizures were Jacksonian in type, starting on right side. Patient had a paralysis of right arm and leg in the intervals between this series of convulsions.

1/10/49

10. 1:30 p.m. Generalized tonic-clonic seizure. Eyes to left. Incontinent, followed by nausea and vomiting.

1/19/49

11. Convulsive seizure.

B3—operation 10/5/48. Venous Ligation.
Returned from operating room at 1:20 p.m.

10/6/48

1. 2:30 p.m. Convulsion lasting one minute, beginning on right side, becoming generalized.
2. 3:20 p.m. Convulsion starting with right side twitching, becoming generalized and stronger in nature, lasting 2 minutes.
3. 5:10 p.m. Body twitching, beginning on right side, lasting 30 seconds.
4. 6:55 p.m. Generalized convulsion, lasting one minute.
Phenobarbital sodium 1 gr at 7:00 p.m.
5. 7:38 p.m. Right side twitching first, becoming stronger and more generalized, both eyes deviating up. Convulsion lasted one minute.
6. 10:30 p.m. Generalized convulsion lasting one minute, beginning with right side twitching. Eyes deviating downward.

10/8/48

7. 2:45 p.m. Generalized convulsion lasting one minute. Head and eyes deviating to left side.
8. 4:10 p.m. Left side twitching, becoming generalized, lasting 30 seconds.
9. 7:00 p.m. Generalized convulsion, beginning on left side, lasting 30 seconds.
10. 9:00 p.m. Generalized convulsion, beginning on left side, lasting 45 seconds.

Phenobarbital sodium 2 gr at 9:15 p.m.

This patient had a series of 10 convulsive seizures over a period of 3 days. Note: Seizures were Jacksonian in type, beginning first on the right, then on left side. They began 24 hours after operation. Patient did not have any seizures on October 7, 1948, or for a period of 16 hours, and was not receiving any medication during this time. Medication began 10/8/48 and was discontinued 10/13/48 (6 day period), during which time she received 27 grains of Diphenylhydantoin sodium (1-1/2 gr t.i.d.) and 18 grains of phenobarbital (1 gr t.i.d.)

B4—operation 10/5/48. Venous Ligation.
Returned from operating room at 7:25 p.m.

10/6/48

1. 7:40 p.m. Generalized convulsion, beginning on left side, lasting one minute.
2. 7:48 p.m. Generalized convulsion, beginning on left side, lasting one minute.
3. 10:35 p.m. Generalized convulsion, beginning on left side, lasting one minute.

This patient had a series of 3 convulsions beginning 24 hours after operation. Note: Seizures were Jacksonian in type, beginning on the left side. Patient had a left hemiparalysis. Deceased 10/7/48 at 1:48 a.m.

B6—operation 10/6/48. Venous Ligation.
Returned from operating room at 8:20 p.m.

10/8/48

1. 2:00 a.m. Generalized convulsions lasting 3 minutes.
2. 8:30 a.m. Convulsion lasting one minute beginning with left arm twitching, involving only the upper extremities.
3. 2:30 p.m. Convulsion lasting 2 minutes, beginning with left arm twitching, involving only the upper extremities. Eyes deviating to the right side.

This patient had a series of 3 seizures. Medication began 10/8/48 and was discontinued 10/13/48 during which interval he received 27 grains of Diphenylhydantoin (1-1/2 gr t.i.d.) and 18 grains of phenobarbital (1 gr t.i.d.). Note: Seizures were Jacksonian in type, beginning on the left side. Patient had no seizures until 30 hours after operation.

B12—operation 10/12/48. Venous Ligation.
Returned from operating room at 1:15 p.m.

10/12/48

1. 2:45 p.m. Generalized convulsion lasting 30 seconds.
2. 3:45 p.m. Left and right arm twitching only, 30 seconds duration.

3. 5:05 p.m. Generalized convulsion lasting 30 seconds, beginning on left side.
4. 7:30 p.m. Generalized convulsion lasting 30 seconds, beginning on left side. Moderate paresis on left side.

Phenobarbital sodium 2 gr.

10/13/48

5. 3:50 a.m. Facial twitching only with deviation of eyes to the right side.
6. 4:40 a.m. Generalized convulsion lasting 3 minutes.
7. 12:00 noon. Twitching of face only, lasting one minute.
8. 12:15 p.m. Stronger seizure involving face and head. Eyes deviating to the left side; lasting one minute.
9. 12:30 p.m. Three consecutive seizures involving mouth and face. Eyes deviating to the right side, lasting 30 seconds each.

10/14/48

10. 5:40 a.m. Generalized seizure lasting 2 minutes, beginning with twitching of left hand.
11. 12:15 p.m. Generalized seizure lasting 30 seconds, beginning on left side.

This patient had a total of 14 seizures. Medication began 10/13/48 and was discontinued 10/25/48. During this time she received 16 grains of phenobarbital.

Note: Seizures Jacksonian in type, beginning on left side.

B13—operation 10/13/48. Thalamotomy.
Returned from operating room at 2:15 p.m.

10/14/48

1. Starting at 10 a.m. patient had an almost continual series of involuntary twitchings of left shoulder followed by stiffening of entire body, but no apparent loss of consciousness. This lasted for about 4 hours during the day, then stopped.

Note: Seizures Jacksonian in type, starting on left side. This patient had a left hemiparesis.

B14—operation 10/14/48. Thalamotomy.
Returned from operating room at 5:00 p.m.

10/15/48

1. 3:45 a.m. Twitching of lower extremities, followed by jerking of head with eyes deviating to the left side, lasting one minute.

10/19/48

2. 10:00 p.m. Seizure beginning on left side becoming generalized, lasting 3 minutes.
3. 2:30 p.m. Generalized seizure beginning on left side, lasting one minute.

Note: Seizures were Jacksonian in type, beginning on the left side. This patient had a total of 3 seizures over a period of 4 days. Four days passed between first and second seizure. This patient had left hemiparalysis.

A8—Topectomy in first Columbia-Greystone project. Preoperative seizures, last record being 10/6/48, 3:00 p.m. Seizure lasting 3 minutes with deviation of eyes to right side. Operation: Extension of topectomy 10/20/48.

12/27/48
While home on Christmas visit, he attended a motion picture show by himself. While there, 1:30 p.m. he had a seizure. Nothing of the pattern is known. No other seizures were reported.
Note: Seizures focal in type.

1/31/49
4:00 p.m. Eyes deviated to right. Tonic-clonic generalized movements for one minute, followed by 5 minutes during which he did not speak or arise from the floor. After 10 minutes, he was apparently clear.

TRANSIENT CHANGES IN NEUROLOGIC SIGNS AND SYMPTOMS FOLLOWING THE OPERATIVE PROCEDURES

This report is concerned with the permanent neurologic alterations, and the transient occurrence of incontinence and convulsive seizures that followed the operative procedures.

It was thought advisable, however, to report in addition the transient neurologic changes which occurred in the immediate postoperative period. Particular attention was given to the following: (a) level of consciousness including awareness and speech production; (b) motor power; (c) convulsive seizures; (d) incontinence.

B1—Venous Ligation. 10/4/48.

a. From the day of operation, patient was aware of her surroundings and capable of spontaneous screaming. By the second postoperative day she would follow simple commands. By the sixth day she would answer yes and scribble when asked to write her name. By the eighth day she was capable of simple statements and appeared fully alert. By the twentieth day speech was fully recovered. There remained some deterioration in handwriting.

b. On the day of operation there were purposeless movements of all extremities. For the first 3 days there was frequent champing motion of the jaws. On the third postoperative day weakness in the right upper extremity was noted. This had disappeared by the eighth day.

c. No convulsive phenomena were noted at any time.

d. Incontinence was noted from the first to the ninth postoperative day.

B2—Venous Ligation. 10/4/48. (Marked brain edema.)

a. Semi-coma for first 2 postoperative days. On third day would respond to commands. On the fifth day was more alert. She was aphasic for 12 days. On the seventeenth day she was capable of a few words. On the twenty-first day it was noted that she could read without difficulty. By the end of the first month, her speech was similar to that of the preoperative period. There remained less accuracy in performing the serial sevens test.

b. From the day of operation she had a right hemiparesis that gradually cleared over a period of 3 weeks.

c. There were multiple seizures on the day of operation and for the first 3 postoperative days and subsequent, seizures 98 and 107 days after operation.

d. Patient was incontinent from the first to the sixteenth postoperative day.

B3—Venous Ligation. 10/5/48.

a. Moderate awareness. There was no speech for the first 3 postoperative

days. Residuum of motor decomposition in handwriting and paucity in description.

b. On the first postoperative day, there were fine generalized tremors. Transient weakness of left side following seizures and generalized weakness for approximately one month that was hard to evaluate. Permanent residuum of fine tremor in outstretched hands.

c. Multiple convulsive seizures on first and third postoperative day.

d. Incontinent from first to eighth postoperative day.

B4—Venous Ligation. 10/5/48.

a. On first postoperative day showed some awareness of short duration. Patient did not speak following operation. Death at beginning of third postoperative day.

b. Generalized spasticity, greatest degree on right. Bilateral plantar extension, absent abdominals. Periodic flexion of right arm.

c. Convulsive seizures on first and second postoperative day.

d. Incontinent from operation until death.

B5—Venous Ligation. 10/6/48. (Moderate brain edema.)

a. Aware and capable of speech from the beginning of the postoperative period.

b. Slight lower left facial weakness noted from the second to the ninth postoperative day. Moderate dyssynergia in left hand. This was imperceptible after the thirtieth postoperative day.

c. No convulsive seizures.

d. No incontinence.

B6—Venous Ligation. 10/6/48.

a. Aware on the first postoperative day and spoke with hesitancy. Over the next 5 days there followed a gradual resumption of about the same volume and amplitude that he was capable of in the preoperative phase.

b. No paralysis.

c. Multiple seizures on the second postoperative day.

d. Incontinent only with seizures.

B7—Venous Ligation. 10/7/48. (Wound infection with subsequent removal of bone flap on 11/4/48.)

a. Aware though hesitant in speech production from the first postoperative day. The latter was improved over the next few days. No speech difficulty was discernible 10 days after the operation.

b. No paralysis.

c. No convulsive seizures.

d. No incontinence.

B8—Venous Ligation. 10/7/48. (Cortical atrophy noted.)

a. On the first postoperative day patient was indistinct in word production. This rapidly cleared in the next few days. There remained minor decomposition in handwriting.

b. No paralysis. Abdominals absent.

c. No convulsive seizures.

d. No incontinence.

B9—Venous Ligation. 10/8/48.

a. Aware, spoke on first postoperative day. Slight decomposition in handwriting was noted when tested 20 and 30 days after operation.

b. No paralysis although he continued to complain of generalized weakness. Fine tremor in outstretched hands that persisted.

c. No convulsive seizures.

d. Incontinent on second and third postoperative day.

B10A—Venous Ligation. 10/8/48.

a. Aware, spoke on first postoperative day. Transient diminution of awareness on second and third postoperative day dramatically relieved by wound drainage.

b. No paralysis. Absent abdominals. Generalized weakness associated with infection and bed rest. Recovered by second month.

c. No convulsive seizures.

d. Incontinent on second and third postoperative day. (Coincident with fever.)

B11—Venous Ligation. 10/11/48.

a. Aware, spoke on first postoperative day.

b. No paralysis.

c. No convulsive seizures.

d. No incontinence.

B12—Venous Ligation. 10/12/48.

a. Aware but lacking in speech on first postoperative day. Fully alert and capable of speech on fourth postoperative day.

b. No paralysis but left weakness following convulsive seizures.

c. Multiple convulsive seizures on day of operation and first 2 postoperative days.

d. Incontinent with seizures.

B13—Thalamotomy. 10/13/48. (Left and then right thalamus incised.)

a. Semi-stuporous for first 2 postoperative days. On the third and fourth days he would follow simple commands. He made no effort to speak but on the seventh postoperative day wrote his name and a group of unconnected words. On the tenth postoperative day he would make monosyllabic answers. On the eighteenth day he talked with reluctance. During the following month there was improvement in his speech but there remained a deterioration in handwriting, description, and in serial sevens. He had reverted to a "word salad." More pronounced than that of the preoperative period.

b. Immediately following operation, there was left hemiparesis that was greatly improved by the twenty-fifth postoperative day. There remained a left lower facial weakness and a fine tremor in the outstretched hands.

c. There were multiple seizures on the first postoperative day.

d. There was incontinence for the first 13 days following the operation.

B14—Thalamotomy. 10/14/48.

a. On operative day appeared alert but did not speak. The following morning spoke. On the second postoperative day became semi-stuporous. After drainage of wound his alertness returned in part but over the next 8 days there was some diminution in alertness and only an occasional word was spoken. On the twentieth postoperative day he spoke with reluctance and in monosyllables.

There remained a paucity in speech production, a tendency to perseverate, and some deterioration in handwriting.

b. Immediately postoperatively no paralysis was noted. On the second day a left hemiparesis was observed which gradually improved over the next 24 days. There remained a slight left lower facial weakness.

c. Convulsive seizures on the first and fifth postoperative day.

d. Incontinent for the first 15 days following operation.

B15—Thermocoagulation. 10/15/48.

a. No significant postoperative change in level of consciousness or level of speech.

b. No paralysis. There remained a fine tremor in the outstretched hands.

c. No convulsive seizures.

d. No incontinence.

B16—Thermocoagulation. 10/18/48.

a. No significant postoperative change in level of consciousness or level of speech.

b. No paralysis.

c. No convulsive seizures.

d. Incontinent for first 2 postoperative days.

A8—Extension of Topectomy. 10/20/48.

a. Alert a few hours after operation with clear speech. On the first postoperative day, speech was limited to single words or phrases. These were commonly slurred. On the second postoperative day, his speech was clear but limited. On the eighth postoperative day, he spoke in a manner similar to that of the preoperative period.

b. No paralysis. There remained a fine tremor in the outstretched hands.

c. Seizures 68 and 103 days after operation.

d. Incontinent for the first 7 postoperative days. This latter is hard to evaluate because of the extraordinary indifference exhibited by the patient during this period.

B17—Transorbital Lobotomy. 10/28/48.

a. Slight confusion on day of operation. On the second postoperative day was fully alert with coherent speech. There remained a paucity in description.

b. No paralysis.

c. No convulsive seizures.

d. No incontinence.

B18—Transorbital Lobotomy. 10/28/48,

a. Moderate confusion on operative date. On first postoperative day alert but speech similar to that of preoperative state. There remained slight deterioration in handwriting.

b. No paralysis.

c. No convulsive seizures.

d. No incontinence.

B19—Transorbital Lobotomy. 10/28/48.

a. Slight confusion on operative date. No significant alteration in level of consciousness or speech.

b. No paralysis.
c. No convulsive seizures.
d. No incontinence.

B20—Transorbital Lobotomy. 10/28/48.

a. On operative date responded when spoken to. On fourth postoperative day exhibited echolalia followed by his usual speech. A similar episode took place on the twenty-fourth postoperative day. Since the latter date, his speech has been similar to that of preoperative phase.
b. No paralysis.
c. No convulsive seizures.
d. No incontinence.

B21—Transorbital Lobotomy. 10/28/48.

a. After minor confusion on the operative day, she reverted to her usual level of consciousness and speech production.
b. No paralysis.
c. No convulsive seizures.
d. No incontinence.

B22A—Transorbital Lobotomy. 10/28/48.

a. Alert and usual speech production from operative day.
b. No paralysis.
c. No convulsive seizures.
d. No incontinence.

B23—Transorbital Lobotomy. 10/28/48.

a. Alert and usual speech production from operative day.
b. No paralysis.
c. No convulsive seizures.
d. No incontinence.

B28—Transorbital Lobotomy. 10/28/48.

a. Alert and usual speech production from operative day.
b. There remained fine tremor in the outstretched hands.
c. No convulsive seizures.
d. No incontinence.

A10—Transorbital Lobotomy. 10/28/48.

a. Immediately following the operation, the patient was confused and lacking in speech production. On the second postoperative day, he spoke when addressed and then in monosyllables. These were not always clear. With apparent improvement on the thirteenth postoperative day, he was noted to have defects in both receptive and expressive functions that are described elsewhere in detail. Thirty-six days following the operation, little defect in speech could be noted. Three months following operation he again exhibited minor defects in expressive and receptive functions of speech.
b. No paralysis.
c. No convulsive seizures.
d. Having been occasionally incontinent prior to operation, following operation he was incontinent. After postoperative confusion cleared incontinence occurred less often. At the end of 3 months its incidence had again increased.

B10, B22, B24, B25, B26, B27 who received no operations showed no changes in level of consciousness, speech production, motor disability, convulsive seizures, or incontinence.

SUMMARY

This discipline assumed the responsibility of a general neurologic survey of 32 patients before and after the operative period. Twelve of these received venous ligations, B1, B2, B3, B4, B5, B6, B7, B8, B9, B10A, B11, B12; 2, thalamotomies, B13, B14; 2, thermocoagulations, B15, B16; 9, transorbital lobotomies, B17, B18, B19, B20, B21, B22, B23, B28, A10; one, an extended topectomy, A8; and 6 were used as controls, B10, B22, B24, B25, B26, B27.

Dramatic and profound changes took place in the immediate postoperative period in 5 of those who received venous ligations and the 2 who received thalamotomies. These included one death, B4, and varying degrees of coma, aphasia, paresis, incontinence, and convulsive seizures, B2, B3, B4, B6, B12, B13, B14. Six were less seriously affected, B1, B9, B10A, B16, A8, A10. Twenty-one, including the 6 controls, were essentially unaffected.

After 3 months, there remained insignificant neurologic residua except for a left lower facial weakness in one, B13, and recurrent seizures in 2, B2 and A8.

Chapter 6

OLFACTION

Bernice M. Wenzel

The purpose of the present investigation was to measure olfactory sensitivity by determining the thresholds for odor identification before and after the various brain operations described in the preceding chapters. With the possible exception of those cases undergoing transorbital lobotomy it was not expected that impairment in acuity would occur. In this operation the cutting instrument might damage the area shown by previous research to be critical for olfaction, viz., the olfactory bulbs, to such an extent as to leave the patient anosmic or with markedly reduced sensitivity. It is doubtful whether damage to other parts of the complicated olfactory pathway would have any measurable effect on thresholds.

The apparatus used was a form of the Elsberg olfactometer for blast injection (Elsberg and Levy, '35) and consisted of a rubber-stoppered 500 cc glass bottle with inlet and outlet tubes for passage of air. The bottle is half filled with distilled water and the odorous material floated on top if liquid or suspended just above the surface in a glass dish if solid. The bottle is sealed and the enclosed air is allowed to become saturated. To deliver a stimulus, a measured amount of excess air from the room is injected into the bottle by means of a syringe. It is then released through a nosepiece to the subject by opening a glass stopcock. The volume (in cc) of this blast is the measure of stimulus intensity. The subject is asked to insert the nosepiece at an angle of 45 degrees, to hold the other nostril closed, to open his mouth, and hold his breath when the experimenter says "Ready."

Although it is possible to construct an olfactometer incorporating more controls over significant features of the stimulus than does the Elsberg model, the latter was selected for use for several reasons. It is readily portable, it can be duplicated easily so that each test substance can be used in its own separate system, it requires only common accessible equipment in its construction, and above all, it does not make excessive demands on the patient and it is acceptable to him.

Three test substances were used: coffee, phenyl ethyl alcohol, and peppermint oil in that order. The first 2 are pure olfactory stimulants while the third, peppermint, stimulates the trigeminal nerve as well. Coffee and peppermint are very familiar odors but phenyl ethyl alcohol is strange to anyone outside the aromatics industry although reminiscent of many perfumes and especially of the odor of roses. Phenyl

B10, B22, B24, B25, B26, B27 who received no operations showed no changes in level of consciousness, speech production, motor disability, convulsive seizures, or incontinence.

SUMMARY

This discipline assumed the responsibility of a general neurologic survey of 32 patients before and after the operative period. Twelve of these received venous ligations, B1, B2, B3, B4, B5, B6, B7, B8, B9, B10A, B11, B12; 2, thalamotomies, B13, B14; 2, thermocoagulations, B15, B16; 9, transorbital lobotomies, B17, B18, B19, B20, B21, B22, B23, B28, A10; one, an extended topectomy, A8; and 6 were used as controls, B10, B22, B24, B25, B26, B27.

Dramatic and profound changes took place in the immediate postoperative period in 5 of those who received venous ligations and the 2 who received thalamotomies. These included one death, B4, and varying degrees of coma, aphasia, paresis, incontinence, and convulsive seizures, B2, B3, B4, B6, B12, B13, B14. Six were less seriously affected, B1, B9, B10A, B16, A8, A10. Twenty-one, including the 6 controls, were essentially unaffected.

After 3 months, there remained insignificant neurologic residua except for a left lower facial weakness in one, B13, and recurrent seizures in 2, B2 and A8.

none of the different kinds of damage had any unique or predictable effect on olfactory thresholds. Changes occurred almost equally for all substances, showing that neither olfactory nor trigeminal sensitivity was exclusively involved. Some fluctuations in thresholds from day to day can be expected even in normal subjects. With abnormal subjects, the attitudinal changes which account for some of the variation in normals are greater in many cases. It is somewhat surprising that the amount of variability from first to second testing was not higher for these subjects under these conditions. For the 4 control patients, an average of 0.8 thresholds were lowered and 1.8 raised. The difference between these 2 averages can be accounted for in the data of one patient whose nose seemed very stuffy on the postoperative test.

Some qualitative results are worth mentioning. As the intensity of a given substance was changed, some patients changed their identification of the substance. They seemed to have ready a store of odor names, probably with special significance for them but with no apparent relation to the test material. Also, these unique responses were recalled at the time of the second test when each patient was asked what he remembered of the first test. A few patients gave color names rather than odor names. Some showed great perseveration in reporting the same substance for all 6 trials. Some identified substances in terms of situations rather than materials. When asked specifically for associations, i.e., what he was reminded of, most patients gave very prosaic and common responses despite the experimenter's attempt to elicit, by an indefinite question, more personal responses.

Olfaction is rarely used by the average person for fine discriminations, but it contributes enormously to affective life. It is felt that a restructuring of the procedure for the purpose of evoking more responses of a qualitative nature might yield some valuable information about the individual patient's fantasies, associations, and significant memories. Any further work in olfaction with similar subjects would probably prove most profitable if conducted along these lines, since the hypothesis of no change in thresholds has been supported.

CONCLUSIONS

1. There was no consistent effect of any of the operations in raising or lowering the threshold for any of the substances.

2. On the average, more thresholds remain the same after operation than show variation. The amount of fluctuation is about what can be expected from one test to another under the measurement conditions of the present experiment.

3. A variety of qualitative responses were recorded which, it is felt, could be expanded upon to advantage with another group of patients.

ethyl alcohol and peppermint oil were used in liquid form; the coffee was ground each time from roasted coffee beans and used as a solid.

Preoperative testing was done from 1 1/2 to 2 months before operation and from 10 days to one month after operation. Twenty-two experimental and 4 control patients were tested individually, once before and once after operation, according to the following procedure. A few control stimuli from a bottle containing only distilled water were given first to acquaint the patient with the task and to see whether he would report odors when there were none. Next the thresholds for the test substances were measured twice, in the right nostril first and then in the left. The order of presentation of the substances for each nostril was always the same so that a familiar substance, coffee, came first and the most irritating to the membranes, peppermint oil, was last. Thresholds were measured according to the psychophysical method of minimal change in which very small stimulus intensities are presented first and then are gradually increased until the subject reports a sensation but not necessarily identification. In our case the stimulus intensity was increased past the point of mere sensation until a correct identification was given or the capacity of the syringe was reached. Instructions were limited to the question, "What was that?" or "What did that smell like?" for each discrete stimulus. The patient was free to believe, if he chose, that a series of different intensities of one substance was a series of different odors. Whenever the patient named the odor correctly, he was asked also to tell what it reminded him of. Pre- and postoperative procedures were identical except that, before beginning the latter, each patient was asked to tell what he remembered of the preoperative test.

The chief source of error in this procedure lay in the inability of the patients to follow the directions consistently. At times the placement of the nosepiece was poor or, more important, the patient sniffed through the nosepiece thus drawing up a larger volume of odorous material than was intended. Every effort was made to avoid these occurrences by careful instruction, practice, and constant supervision. They are recognized as existing, however, and, hence, as making suspect attempts to establish thresholds at any but relative values. That is to say, we can determine for a given patient the rank order of his thresholds for the different substances, for the 2 nostrils, and/or for the 2 periods of testing. Since the last relationship was the purpose of the investigation, the technique can be considered adequate.

In order to test the hypothesis that the olfactory thresholds had not been raised by the operation, each patient's data were tabulated according to whether his thresholds had increased, decreased, or remained the same. Six changes were possible for each patient, one for each of the 3 substances in each nostril. For the 22 experimental patients, the average number of thresholds which were higher postoperatively was 1.2. On the other hand, the average number of lower thresholds postoperatively was 1.3. These changes, in both directions, were spread uniformly through the various operations, suggesting that

All of these methods are dependent upon the keenness of the observer in watching for nystagmic jerks and any blinking or wandering of attention of the examiner results in inaccuracy. A considerable number of years ago, James Q. Holsopple constructed a modification of the Bárány Chair, which was itself based upon the work of Mach. This chair incorporated a 35 millimeter ophthalmograph camera, which made it possible to obtain permanent records which could be read and reread under the most exacting conditions. Observations could therefore be checked by more than one person and are not dependent upon the degree of attention which the experimenter is able to give at the time of the test. In addition, it is possible to check many of the characteristics of nystagmus, which could not otherwise be simultaneously investigated. Holsopple's approach also incorporated the principle of using constant acceleration, which could be varied as desired, with the guarantee that the external stimulus would remain constant.

The postoperative testing in the first Columbia-Greystone project was carried out by this method and was modified and expanded for the present study. Working closely with Mr. Wittkuhns of the LAB Corporation, the present machine was constructed and, on the basis of modifications made in the course of the present study, is believed capable of adequately testing vestibular function.

The chair (Plate III A) is similar to the Bárány Chair insofar as it is a revolving chair but the base is on ball bearings, which allows rotation with a minimum of friction. The rate of revolution is determined by a pulley going from the base of the chair up a hollow iron rod and so arranged that iron castings of different weights can be hung from the pulley so that the rate of acceleration can be varied. The chair is turned from the neutral position one full revolution before the subject enters it and a brake is then applied which fixes it until the test is ready to begin. Since the weights hang free, their fall is proportionate to that of gravity and since a falling body descends at constant acceleration, the chair also revolves according to this principle. It is logically felt that the stimulus of vestibular function is primarily an acceleratory one, since the anatomy of the vestibular apparatus is such that maximum response of the otoliths would be caused in this manner.

When the test is ready to begin, the foot brake is released and the chair revolves 360 degrees at a fixed rate of acceleration. Rotation is not stopped abruptly but is allowed to continue through a deceleratory phase, which is also fixed, since momentum is exerted against a fixed weight. When the chair has slowed to its stopping point, an automatic brake goes into action so that there is no reverse movement. The chair has been so constructed that the point at which rotation begins and the point at which movement stops is automatically recorded on the photographic film in the ophthalmograph.

For obtaining a permanent record of nystagmus, a light shining on the patient's conjunctiva is reflected into a moving picture film. Samples of such records are presented in figure 33. The camera is a permanent part of the machine and rotates with the patient during the test period. It thus becomes possible to record nystagmus not only pre- and postrotationally, but also during the actual physical rotation. An American Optical Company ophthalmograph has been found the most suitable instrument but certain modifications are needed since the instrument was primarily designed to study reading disabilities. Since the machine was not built originally to be rotated, the mirror in the machine needs reinforcement, since otherwise, during the course of the rotation, it tends to be deflected in such a manner that the light reflected from the

Chapter 7

VESTIBULAR FUNCTION AND AUTOKINESIS[8]

Nathan S. Kline

VESTIBULAR FUNCTION

Introduction

The purpose of testing vestibular function is two-fold. First, little is known of the course of vestibular pathways above the mid-brain and it is felt that the present series of operations may give some indication as to possible cortical influence upon this function. Second, at the present time, there is considerable discussion of the concept of "physiologic readiness" and it is felt that vestibular function is probably one measure of this type of response, which some investigators claim is reduced in schizophrenia. According to Hoskins ('46) vestibular function is reduced in schizophrenia and it was felt that if any of the patients recovered it would be valuable to see whether a change in vestibular function occurred.

Apparatus[9]

The greatest difficulty in testing vestibular function is that instrumentation is inadequate. Three methods are in general use. All have disadvantages. The method of galvanic stimulation has the defect that the stimulus is diffuse and that other nerves may be stimulated in addition to those supplying the vestibular apparatus. The caloric method suffers in that it is almost impossible to apply a constant stimulus. There is a tendency for the temperature of the water to change, the size of the canals vary from person to person, small amounts of cerumen in the ears materially alter the results, and finally, apparatus to deliver a continuous stream of fluid under constant pressure is impractical. The rotational method in common use (with the Bárány Chair) suffers from the defect that both sides of the body are stimulated simultaneously and constancy of stimulation is difficult to obtain since it is dependent upon the strength and ambition of the tester when he spins the chair.

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8. The author wishes to express his appreciation to Ashton Tenney, Andrew Vigglano, Richard Krum, and Mrs. Jane Olmer, for their invaluable assistance in the technical or statistical aspects of the work.

9. The contribution of Bruno A. Wittkuhns of the LAB Corporation, Summit, New Jersey, and of Mr. Wittkuhns' assistants, Gil Hill and Frank Van Trunk, Jr. in devising and constructing the apparatus, made possible many improvements of testing, which could not otherwise have been made.

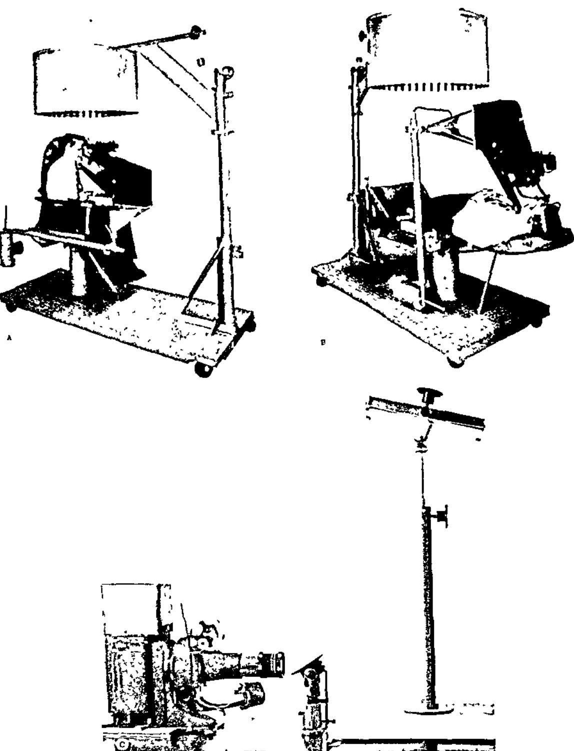


Plate III. A. LAB modification of Holsopple vestibular chair with optokinetic attachment. Position for commencement of acceleratory stimulation of vestibular apparatus with head in vertical position. B. Apparatus shown in Plate III A. Position for commencement of acceleratory stimulation of vestibular apparatus with head in horizontal position. The rod under the subject's back does not touch the base of the apparatus. C. Apparatus for projecting film record on graph paper.

conjunctiva is not always directed onto the film. When the patient is placed in a horizontal position, the ophthalmograph can be swung into position, but here again, since the American Optical Company apparatus is not designed for use in this position, it is found that the spring returning the mirror to the proper refracting angle is not sufficiently strong. It is considered essential that photographic developing equipment be present and the films developed as soon as possible in order to be certain that a satisfactory record has been obtained.

As can be seen from Plate III A and B the patient can be tested in both the vertical and the horizontal positions. It would be possible, with minor variations, to test the patient in practically any desired position. The machine is also provided with an attachment to test optokinetic nystagmus, which can be induced by having the patient's environment revolve about him. To test this function, a circular drum, 4 feet in diameter was constructed and lined with alternate black and white vertical stripes 1 inch in width. The drum can be raised when not in use and lowered about the patient so that it completely fills his field of vision when optokinetic function is to be tested.

As will be described later, in testing vestibular nystagmus, considerable importance attaches to whether the patient fixates or does not fixate upon a point during rotation of either himself or environment. In the first Columbia-Greystone project some difficulty was experienced because the focal distance was so short that fatigue was incurred and when the eyes "broke," i.e., fixation was momentarily abandoned, a nystagmoid recording appeared on the film. In the present machine, to eliminate this, aerial gun-sights were used and each eye was given its own independent fixation point, which was at infinity. It was necessary to use 2 sets of gun-sights, one for testing rotational nystagmus and the other for fixating during the course of the tests for optokinetic nystagmus.

The only modification of the machine made subsequent to the present study has been the introduction of a light source about 4 inches higher than the present one (resting on top of the ophthalmograph), which makes focusing a less cumbersome task.

For those not familiar with an ophthalmograph, it should be explained that the light reflected from the conjunctiva enters lenses which can be adjusted so that the point of light focuses on a piece of ground glass. When it appears as distinct a pin-point as possible, a switch is thrown so that the light, instead of remaining focused on the ground glass, is then interrupted by a mirror, which reflects the light onto the film. There is an unobstructed view of the focusing glass when rotational nystagmus is being tested but it is necessary to provide a door in the cylinder used for testing optokinetic nystagmus. After the light has been focused, the door in the cylinder can be closed and is then practically invisible within the machine. A separate weight is provided in order to induce optokinetic nystagmus by the same principle of fixed acceleration and deceleration.

Direct reading of the 35 millimeter film is an extremely tedious procedure. A method was therefore devised not only to enlarge the film but also to project it directly upon graph paper so that the scoring becomes a relatively simple matter. The machine is so constructed that enlargement can be considerably varied, as can the area of projection. This apparatus is shown in Plate III C.

Method

In order to establish baselines for normal variation, each of the patients was tested 3 times preoperatively. Postoperatively the patients were tested after 2 weeks and again after 3 months. With rare exceptions, the patients were run through the tests in the same order; namely, rotational nystagmus in

the sitting position, rotational nystagmus lying down, and finally, optokinetic nystagmus. All tests were administered by the same technician except the second postoperative test, which was jointly administered since a new technician was being trained to operate the machine. All the films were read twice by the same experimenter and 20 per cent of them were checked by a different experimenter. In case of more than very slight disagreement, both researchers reread the films independently and in all cases on the rereading, agreement was reached with less than 5 per cent disparity. Tests were scheduled so that pharmacological procedures or other techniques (such as air encephalograms) had not been administered within a time period that might have influenced the vestibular performances. When a patient was uncooperative, efforts were made on at least 5 separate occasions to urge him to submit to the testing.

Before a patient was called for, his schedule was checked with the Ward to determine that no procedure that might interfere with results had recently been administered. A Log Book was kept in which any unusual reactions of the patient were recorded during the period of his testing. When the patient and the vestibular chair were brought together for the first time, the patient was given an opportunity to inspect the chair and the procedure was very briefly explained. Due to the formidable appearance of the machine reassurance was sometimes necessary. In one or 2 cases, it was necessary to demonstrate on a third party exactly what happens before the subject will allow himself to be tested.

During tests the camera is swung out of the way, the patient seats himself in the chair, which has already been revolved to the starting position and locked there, and the camera is then swung back into position (Plate III A). The patient places his chin on the chin-rest and the height of the camera is then adjusted for maximum comfort. The braces against the temples are applied, the aerial gun-sights turned on, and the patient asked to look at "the spot." The other lights in the room are then turned off, with the exception of a very dim shielded bulb which is used for clocking, by means of a stopwatch, the 15 second prerotational and the 30 second postrotational periods. The shield on the focusing box is lifted and the lenses which pick up the conjunctival reflection are then adjusted until the reflections are properly centered, parallel, and of pin-point size. The shutter is closed and the camera started. After a 15-second stationary run, during which spontaneous nystagmus is recorded, the foot gear is shifted and the machine automatically unlocks and rotates with fixed acceleration for 360 degrees. Throwing the foot gear automatically interrupts the electrical circuit in such a manner that a light within the camera is turned on, marking the exact spot on the film at which physical rotation begins. The rotation continues beyond the 360 degrees, this time with fixed deceleration and when momentum entirely ceases, the machine automatically locks itself again, at the same time recording on the film the exact point at which movement ceases. The camera then continues running for an additional 30 seconds, during which postrotational nystagmus is recorded.

Prior to the beginning of motion, it is explained to the patient that he is to keep his eyes fixated on the point of light until the test is completed. The only verbal instructions given in the course of the test occur if the patient allows his eyes obviously to wander away from the point of fixation. He is then instructed to keep looking at the "spot."

The first run is taken in a clockwise direction and the patient is now left sitting in the chair for a full 3 minutes before beginning the counterclockwise

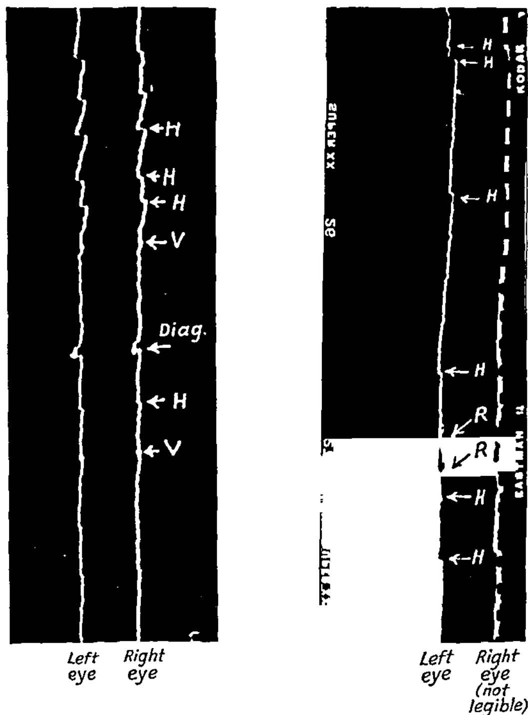


FIG. 33. Example of motion picture record of nystagmus obtained with apparatus described in text. Diag. = diagonal movement of eyes. H = horizontal and V = vertical movements of eyes R = rotational movement. (From "Selective Partial Ablation of the Frontal Cortex" by The Columbia Greystone Associates, Fred A. Mettler, Editor, New York, Paul B. Hoeber, Inc , 1949)

During the period when work on the present project was proceeding, quite a number of consultations were held with Dr. Joseph Hawkins of the Merck Therapeutic Institute, who had developed a method of testing vestibular function in cats, in conjunction with his work on the effects of streptomycin on this function. We had independently both arrived at testing both rotational and optokinetic nystagmus and in many respects the principles of testing were almost identical. In contrast with our cinematographic method of recording, however, Dr. Hawkins had developed an electronic method of recording nystagmus by placing one electrode over the temple and the other electrode between the eyebrows. Simultaneous runs, using both methods of recording, showed a very high degree of correlation. Dr. Hawkins' apparatus possesses the advantages that recordings can be read instantly, and also that nystagmus can be tested with the eyes closed. With our machine it is not possible to test nystagmus without fixating. Disadvantages of Hawkins' machine are that a 2-man team is required to administer the tests and that the machinery is influenced by any vagaries in the flow of electrical power.

RESULTS

As a result of failure to develop films immediately, minor mechanical defects in the apparatus were not discovered until it was too late to retest records which were absent or inadequate. Due to the uniformly satisfactory quality of the films produced by the machine in the first Columbia-Greystone project, it was not anticipated that this

Pt No		Vertical c	Vertical cc	Horizontal c	Horizontal cc	Visual c	Visual cc	Average	Increases	Average % change	Decreases	Average % change	Av Total % change
15	Pre-op	67		70	90			76	3	645	0		+645
	Post-op	70		132	172			129					
16	Pre-op						51	51	1	1510	0		+1510
	Post-op						128	128					
Increase		1		1	1		1	(4)					
Decrease		0		0	0		0	(0)					
Ave %	Increase	45		886	911		1510	838 (+838)					
	Decrease	0		0	0		0	0					
Total average	Pre-op	67		70	90		51	7.0 (+800)	4	1078	0		+1078
	Post-op	70		13.2	17.2		128	12.6					
Average total % change		+45		+886	+911		+1510	+838					

COEFFICIENT of CORRELATION BETWEEN PRE-& POST-OPERATIVE TESTS ROTATIONAL 44 (PE_r = .18)

AVERAGE of ALL READABLE RECORDS
PRE-OPERATIVE 75 SD 54 POST-OPERATIVE 136 SD 62

FIG. 34. Summary of pre- and postoperative rotational data (optokinetic inadequate) *for the 2 patients who were subjected to thermocoagulation.*

problem might arise. A series of test runs, prior to beginning the testing of the patients, produced satisfactory film. Because of the relatively weak spring on the mirror in the ophthalmograph, *some of the* recordings proved to be satisfactory when the spring functioned adequately and others were completely useless when the spring failed to

run. During this period, a card is inserted into the slot provided on the ophthalmograph, which allows the patient's number and the designation of the test to be photographed directly on the film, insuring proper identification at a later date. The same procedure is then repeated for the counterclockwise "vertical" test.

The chair is then adjusted so that the patient can lie comfortably on his back and the camera is swung into position for use in this position (Plate III B). The rotational procedure is repeated with runs first in the clockwise and then in the counterclockwise directions.

The back-rest is raised and the patient returned to a sitting position. After the customary 3-minute wait, the circular drum is lowered about the patient, who is instructed to keep his eyes closed while it is wound up one revolution preparatory for the test. When the drum is in such position that it completely occupies the patient's visual field, the upper gun-sights are turned on and the lower ones turned off. The patient is asked to fixate on this new "spot," which is again observed as though at infinity. The window in the circular drum is opened and the reflected light again focused to pin-point accuracy. The window is then closed and the brake on the optokinetic drum is released, causing it to revolve at fixed acceleration through one complete revolution and again automatically braking when movement ceases. No provisions are made for automatically recording the beginning and cessation of movement on the film for the optokinetic apparatus but this can be done without great additional expense, if it is planned for at the time of construction of the chair. Once again, tests are made in both the clockwise and counterclockwise directions. This completes the test routine for this procedure.

It is considered essential that a small developing unit be provided and all films obtained during the day be developed the same evening so that retests can be made, when necessary. If records are made on 100-foot rolls of film and not developed immediately but sent away for processing only when several rolls have accumulated, it is impossible to learn the quality of the records until possibly too late to retest if necessary.

Previous experimentation with a large number of patients confirmed the work of Walter Leach done at Princeton University with the Holsopple chair that the threshold for nystagmus was approximately 2 degrees per second per second acceleration. Following the principle that minimal adequate stimulation is the most discriminatory, the rate of rotation for the present study (as in the first Columbia-Greystone project) was set at 2-1/2 degrees per second per second. Five, 7-1/2, and 10 degrees per second per second had previously been tried and found to minimize the differences between individuals and for this reason were not used.

Since the ophthalmograph camera is fixed to run at a constant rate of 1 centimeter a second, the conversion to jerks per minute is a simple matter.

In the first Columbia-Greystone project the data were broken down in considerably more detail. The acceleratory phase, the deceleratory phase, and the postrotational record were statistized separately. In addition, the number of "horizontal" jerks were worked up separately and compared to the number of "vertical," the amount of nystagmus going against the prevailing trend, and rotational nystagmus. Either the quantity of some of these types of nystagmus are so small, or the results are proportional to the "horizontal" nystagmus so that in the present study, only the total amount of nystagmus for the entire test is used as the basis for statistical comparisons.

modified the findings upon which the present data rest. However, when the patient does fail to fixate, the record on the film is blurred and usually impossible to score satisfactorily, so that it may be safely assumed that readable records are, with few exceptions, obtained under constant and standarized conditions.

EFFECT OF ACCLIMATION. The question arises as to whether repeated testing reduces the nystagmic response to rotation. Comparisons of first and subsequent tests show no statistically significant variation. The mean rate for clockwise acceleration for the entire group of patients is 14.9 jerks a minute with an S.D. of 9.9. When the first test of each patient is examined separately the mean is found to be 12.0 with an S.D. of 7.3. There is, therefore, a very slight and insignificant increase rather than decrease on tests subsequent to the initial one. Comparison of the first postoperative test of clockwise acceleration with subsequent clockwise acceleration shows both to have a mean of 17.2 with an S.D. of 10.8 in the latter case and 12.1 in the former.

It is found that if a full 3-minute wait is allowed, recovery appears to be complete, as far as statistical evaluation can determine. Another way of ascertaining whether there is acclimation is to compare the clockwise with the counterclockwise tests for both the rotational and optokinetic types of nystagmus. The mean amount of nystagmus per minute for all patients on whom both clockwise and counterclockwise records are available for the same test, administered in immediate continuity, is 15.3 jerks a minute, for clockwise rotation. The mean for counterclockwise rotation on this vertical test (with the patient sitting upright) is 12.6 nystagmic jerks per minute. With the patient in the horizontal position, the clockwise mean is 12.2 and the counterclockwise mean 13.3. For the optokinetic test, the mean is 9.9 nystagmic jerks per minute for clockwise rotation as contrasted with 8.6 nystagmic jerks per minute for counterclockwise rotation. However, 19 of the 30 records having both clockwise and counterclockwise rotation show a decrease from the first to the second test; whereas, only 11 show an increase. Of the 28 horizontal tests, exactly one half increased and one half decreased. In the optokinetic group, presumably involving a different set of neurons, 11 of the 18 decreased, 6 increased, and one remained unchanged.

The average decrease in the vertical group from clockwise to counterclockwise is 6.7 jerks per minute, which gives an average of 33.9 per cent decrease for those patients showing such a decrease. The 11 increases also average 6.7 jerks per minute difference and the clockwise mean is 38.1 per cent less than the counterclockwise mean. In the horizontal group, half the patients show an average increase of 7.0 jerks per minute (36.4 per cent greater clockwise than counterclockwise). In the other half of the patients there is an average of 8.6 jerks per minute increase (averaging 55.5 per cent less clockwise than counterclockwise). In the optokinetic tests, the 11 decreases average

function properly. Although only about 20 per cent of the tests produced satisfactory records, it is still felt that sufficient data have been obtained to draw fairly definite conclusions.

Several facts of major importance emerged from our comparative work with Hawkins. It was found beyond question that the quantity and quality of the nystagmus varied considerably depending upon whether or not the subject maintained fixation. Dr. Hawkins and his assistant, as well as the present author and his technicians, subjected themselves to repeated runs in the chair, in order to clarify these points. Tests were made under a wide variety of conditions and it is clear that many of the discrepancies in the literature are due to failure to note whether the subject does or does not fixate, whether he closes his eyes or allows them to remain open, and whether the room is completely darkened or varying degrees of light are present. The rather wide variation found in some of the patients in the present group can be accounted for by the fact that on one test they fixated adequately but failed to do so during another "run." Considerable investigation is necessary before the work with Dr. Hawkins can be definitely clarified. These findings do not vitiate or nullify the present data since, on satisfactory tests, the patients kept their eyes open, the amount of light in the room was minimal and constant, and fixation was maintained throughout the test. The last of these 3 factors cannot, of course, be guaranteed and does introduce a variable, which may have

Pt. No		Vertical c	Vertical cc	Horizontal c	Horizontal cc	Visual c	Visual cc	Average	Increases	Average %change	Decreases	Average %change	Av Total %change
18	Pre-op	151	190	272				204	0		3	388	−388
	Post-op	104	159	111				125					
19	Pre-op					16.2		162	0		1	57	−5.7
	Post-op												
20	Pre-op	230	180	228	23.9			22.0	1	381	3	261	−96
	Post-op	172	155	315	152			220					
21	Pre-op					11		11	1	2000	0		+2000
	Post-op												
22A	Pre-op	79	73	99	70			80	2	2014	2	300	286
	Post-op	60	145	65	143			103					
28	Pre-op	102				117	57		1	680	2	149	+25
	Post-op					9.3	96	94					
Increase		0	1	1	1	1	1	(5)					
Decrease		4	2	2	1	2	0	(11)					
Ave%	Increase	0	982	381	104.8	2000	680	848 (+581)					
	Decrease	237	151	524	572	117	0	267					
Total average	Pre-op	141	148	200	15.5	97	57	133 (−45)	5	846	11	193	+483
	Post-op	107	153	164	148	93	96	127					
Average total % change		−23.7	+3.6	−178	−45	−34	+680	+37					

COEFFICIENT of CORRELATION BETWEEN PRE & POST-OPERATIVE TESTS

ROTATIONAL .54 (PE_r = .08)

OPTOKINETIC 94 (PE_r = .02)

AVERAGE of ALL READABLE RECORDS

PRE-OPERATIVE	POST-OPERATIVE
132 SD 79	154 SD 112
111 SD 80	120 SD 81

ELIMINATING No 21

PER PT AVERAGE % CHANGE = −46

" " INCREASE-DECREASE AVERAGE % CHANGE = +384

PER TEST AVERAGE TOTAL % = +23

" " INCREASE-DECREASE AVERAGE % CHANGE = +248

FIG. 35. Summary of pre- and postoperative rotational and optokinetic data on patients having transorbital lobotomy.

coefficient of correlation between these 2 is only 16. In the horizontal group, the mean for clockwise rotation is 12.0 with an S.D. of 9.0 and for counterclockwise rotation a mean of 11.4 with an S.D. of 12.1. The coefficient of correlation between clockwise and counterclockwise rotation on the horizontal tests is .24. *On the visual optokinetic tests,*

Pt.No.		Vertical c	Vertical cc	Horizontal c	Horizontal cc	Visual c	Visual cc	Average		Increase	Average %change	Decrease	Average %change	Av Total %change
10	Pre-op	6.3			19.9	9.5	6.5	10.5		2	58.6	2	69.4	−5.4
	Post-op	13.4			20.6	2.6	1.2	9.5						
24	Pre-op	11.7						11.7				1	35.0	−35.0
	Post-op	7.6						11.7						
25	Pre-op	13.2	8.5			4.2		8.6		2	65.1	1	83.3	+15.6
	Post-op	23.7	12.8			0.7		12.4						
27	Pre-op				28.2			8.2				1	75.5	−75.5
	Post-op				6.9			6.9						
Increase		2	1	0	1	0	0	(4)						
Decrease		1	0	1	0	2	1	(5)						
Av %	Increase	89.8	50.6		4.0			24.1	−19.8					
	Decrease	35.0		75.5		71.2	81.5	43.9						
Total average	Pre-op	10.4	8.5	28.2	19.9	5.9	6.5	14.8	−38.5	4	31.0	5	65.8	−25.1
	Post-op	14.9	12.8	6.9	20.8	1.7	1.2	9.1						
Average total % change		+43.3	+50.6	−75.5	+4.0	−71.2	−81.5	−21.7						

COEFFICIENT of CORRELATION BETWEEN PRE-& POST-OPERATIVE TESTS — ROTATIONAL .174 (PE_r = .15); OPTOKINETIC .11 (PE_r = .22)

AVERAGE of ALL READABLE RECORDS

	PRE-OPERATIVE	POST-OPERATIVE
	14.5 S.D. 10.5	14.7 S.D. 10.9
	7.5 S.D. 4.0	3.1 S.D. 1.6

FIG. 37. Summary of rotational and optokinetic data on control cases.

the mean for clockwise rotation is 8.9 with an S.D. of 6.9; whereas the counterclockwise mean is 9.2 with an S.D. of 8.5. The coefficient of correlation between the clockwise and counterclockwise here is .64. For the entire group, the clockwise mean is 7.0 with an S.D. of 8.0 and the counterclockwise mean 7.1 with an S.D. of 7.5. The overall coefficient of correlation of clockwise and counterclockwise tests is .38. The discrepancies between the figures in this paragraph and those in the preceding one are due to the method of grouping used to determine coefficient of correlation and the figures in this paragraph are slightly less accurate. Again, the conclusion is, that although comparison of clockwise with counterclockwise rotation does not show statistically significant differences, nevertheless, there is a slight tendency for acclimation to occur.

RATES OF NYSTAGMUS. Subjectively, there appears to be much more marked movement when the subject is in the horizontal position, since the arc through which he travels is considerably greater than in the vertical position, where vestibular organs are only a few inches from the center of rotation. The fact that the *quantitative* amount of nystagmus is slightly less when the patient is in the horizontal position, regardless of his subjective feelings, indicates either that the rate of acceleration is really the determining factor, or that such marked acclimation occurs that the true result is obscured because *of this factor.* This latter eventuality appears unlikely and could not be demonstrated on the few special runs where it was specifically looked for. The rate

Pt No		Vertical c	Vertical cc	Horizontal c	Horizontal cc	Visual c	Visual cc	Average		Increases	Average %change	Decreases	Average %change	Av Total %change
1	Pre-op	77						77		1	62.3%	0		62.3%
	Post-op	12 5						12 5						
2	Pre-op					39	8 7	6.3		2	449 1	0		+449 1
	Post-op						24 0	33 0						
3	Pre-op							8.2		0		1	25.6	-25 6
	Post-op							6 1						
5	Pre-op		15 5					15 5		1	50.3	0		+50 3
	Post-op		23 3					23.3						
6	Pre-op	13 8						13.8		1	52 9	0		+52 9
	Post-op	21 0						21 0						
7	Pre-op	4 9						4 9		1	61 3	0		+61 3
	Post-op	7 9						7 9						
8	Pre-op	5 9						5 9		1	62 7	0		+62.7
	Post-op	9 6						9 6						
9	Pre-op			9 2	9 6			9 4		1	35 8	1	0 01	+17 4
	Post-op			12.5	9 5			11 0						
10A	Pre-op	8 4		8.3	7 5		5.0	7 3		3	53.2	1	12 0	+36.9
	Post-op	17.3		11 2	8.9		4 4	10.5						
11	Pre-op				3 5			3 5		1	337 1	0		+337 1
	Post-op				15 3			18 3						
12	Pre-op	9.3			11 0		6.2	8.8		3	23 2	0		+23 2
	Post-op	10 8			12 8		8.5	10 7						
Increase		6	1	2	3	1	2	(15)						
Decrease		0	0	0	1	0	2	(3)						
Ave %	Increase	59.0	50.3	35.2	68.2	515.4	238 9	161 2	(+157 8%)					
	Decrease	0	0	0	1	0	2	3						
Total Ave	Pre-op	8.3	15.5	8.8	7.8	3.9	7.1	8.6	(+93 0%)	15	+108 0	3	-3 4	+102.5
	Post-op	13 2	23.3	11 9	11.6	24.0	15.3	16 6						
Average total % change		+59.0	+50.3	+35.2	+46.8	+515.4	+118.6	+137 6						

COEFFICIENT of CORRELATION BETWEEN PRE & POST-OPERATIVE TESTS

ROTATIONAL 47(PE_r = .08)
OPTOKINETIC .312(PE_r = .196)

AVERAGE of ALL READABLE RECORDS

PRE-OPERATIVE	POST-OPERATIVE
9 4 SD 5 4	13 5 SD 7 4
5 5 SD 3 7	17 2 SD 11 5

FIG. 36. Summary of pre- and postoperative rotational data on patients before and after venous ligation.

4.8 jerks per minute (41.8 per cent) and the 6 patients show increases with an average increase of 5.1 jerks per minute (averaging 35.1 per cent greater counterclockwise than clockwise). The impression is gained that although the effect of acclimation does not reach the point of statistical significance, nevertheless, there is a persistant tendency for the first test to show greater responsiveness than subsequent ones. The trend is not uniform, but approximately twice as many patients show reduced vestibular function from the initial clockwise rotation to the subsequent counterclockwise rotation when tested in the vertical position. The fact that horizontal testing shows one-half the patients increasing and the other half decreasing would agree with this hypothesis, since there will be a carry-over of the acclimation effect, inasmuch as the horizontal testing is done immediately subsequent to the vertical testing. The fact that in the optokinetic tests again there are twice as many decreases from clockwise to counterclockwise than in the opposite direction, indicates that there is no apparent carry-over from the rotational type of nystagmic stimulation to the type induced by visual movement and again indicates that in this new field acclimation again occurs.

The mean rate in the vertical test is 13.9 jerks per minute with an S.D. of 6.5 for the clockwise rotation and a rate of 12.5 jerks per minute with an S.D. also of 6.5 for the counterclockwise rotation. The

mixed increases and decreases on individual tests. One of them, when all the tests are averaged, shows a slight decrease; whereas, the other shows a slight increase. The average change for all the controls, when the average of each patient is considered, shows that 4 tests increase after the operative period for an average change of 31.0 per cent and 5 tests show a decrease with an average change of 65.8 per cent. The difference between the 2 tests is, therefore, a decrease of 34.8 per cent. When the total average change for each patient is considered, 3 of them show a decrease and 1 an increase, with the overall change a decrease of 25.1 per cent.

When the data are viewed from the point of view of individual tests (vertical clockwise, vertical counterclockwise, horizontal clockwise, horizontal counterclockwise, visual clockwise, visual counterclockwise) rather than average response per patient, 2 of the tests are found to show only increases, 3 show only decreases, and one shows mixed increases and decreases. Of the 9 test records obtained, 4 increased and 5 decreased. The average increase was 24.1 per cent and the average decrease 43.9 per cent, with the resultant difference of 19.8 per cent decrease. When the total average of "preoperative" scoring (14.8 jerks per minute) is compared with the total average "postoperative" score (9.1 jerks per minute) a decrease of 38.5 per cent is indicated. A final way of viewing the data is to consider the average total percentage change for each of the 6 tests (vertical clockwise, vertical counterclockwise, horizontal clockwise, horizontal counterclockwise, visual clockwise, visual counterclockwise). Here 3 of the changes show an increase and 3 of them a decrease, with an average net change of 21.7 per cent decrease.

The average "preoperative" score on the rotational tests (vertical and horizontal) is 14.5 jerks a minute with an S.D. of 10.5. "Postoperatively," the mean rate of nystagmus per minute is 14.7 with an S.D. of 10.9. On the optokinetic test, the "preoperative" rate was 7.5 jerks per minute with an S.D. of 4.0, which "postoperatively" is reduced to 3.1 jerks with an S.D. of 1.6.

The coefficient of correlation between the "pre-" and "postoperative" tests is .17 for rotational nystagmus, with a probable error of .15. For optokinetic nystagmus, the coefficient of correlation between the "pre" and "postoperative" conditions is only .11, with a probable error of .22. The scattering of results and the low coefficient of correlation indicate that no significant shift occurred between "pre-" and "post-" operative testing, so that it may be assumed that any shifts found in the operative groups are subject only to statistical limitation and are not due to changes in techniques.

VENOUS LIGATION. Adequate pre- and postoperative records on at least one of the 6 tests were obtained on all 12 patients receiving the venolysis operation, with the exception of B4, who had died. Eight of the patients showed an increase only following their operation. One of the patients showed a decrease only and 2 of the patients showed both an increase and a decrease, although in B9 the decrease was only

of nystagmus resulting from optokinetic stimulation is significantly less than for rotational induction. The circular drum revolves about the patient at the same rate of 2 1/2 degrees per second per second, but the resultant nystagmus is considerably less. Since every effort has been made to eliminate optokinetic effect from the rotational tests, with reasonable success, the difference is felt to be a real one. In other words, significantly greater nystagmus is induced by rotation than by optokinetic effects. Theoretically, a combination of these 2 types of nystagmus should increase the rate even further. Although this was not tested for in the present study, upon reviewing the results of the first Columbia-Greystone project it is found that in a series of 100 non-psychotic controls, the average rate of nystagmus is about 35 jerks per minute, and in the psychotic patients, about 47 jerks per minute. The room was considerably lighter during the testing in the first study so that if it can be assumed that vestibular stimulation remained constant, there appears to have been a summative effect of rotational plus optokinetic stimulation.

SPONTANEOUS NYSTAGMUS. In the 100 non-psychotic controls tested in connection with the first project the rate of spontaneous nystagmus was found to be 5.3 jerks per minute with an S.D. of 7.7. In the present group, comparisons are made between those patients having adequate preoperative and postoperative records and here the spontaneous rate of nystagmus in the preoperative group shows an average of 8.1 jerks per minute with an S.D. of 1.9, utilizing all adequate records. When only the first preoperative test is used (a condition which is comparable to the 100 non-psychotic control subjects in the first project) a mean of 7.7 is obtained. This seems to indicate that spontaneous nystagmus is somewhat greater in the patients than in a control group. This bears out the impression gained on the previous study, that responses to vestibular stimulation may increase rather than decrease in schizophrenia; a finding at variance with the conclusion of Hoskins ('46). Postoperatively, the mean amount of spontaneous nystagmus in patients subjected to venous ligation is reduced from 8.2 jerks per minute with an S.D. of 6.8 to 7.1 with an S.D. of 4.3. The patients receiving transorbital operations dropped from a mean of 11.4 jerks per minute to 7.6. In the 2 cases of thalamotomy the preoperative mean is 5.5. Postoperatively adequate records could be obtained on only one patient, who showed no spontaneous nystagmus. In the 2 cases subjected to thermocoagulation, the mean increases from 7.9 to 11.3. In the controls, there is also a shift from 7.5 preoperatively to 5.4 postoperatively, so that none of the results obtained appear to be of statistical significance.

CONTROL PATIENTS. Four of the 6 control patients have some record, both "pre-" and "post-" operatively for the same test, by either the vertical, horizontal, or visual method. Two of the 4 patients on whom results were obtained showed a decrease when all the methods of obtaining nystagmus are averaged. The other 2 patients show

the average increase and decrease is plus 58.1 per cent, which is considerably reduced with the elimination of B21. The difference between the total averages is a decrease of 4.5 per cent and the total average percentage change is an increase of 3.7.

The average preoperative score on the rotational test is 13.2 jerks per minute with an S.D. of 7.9, which postoperatively became 15.4 jerks per minute with an S.D. of 11.2. On the optokinetic tests, the preoperative mean of 11.1 jerks a minute with an S.D. of 8.0 increases to 12.0 with an S.D. of 8.1.

The coefficient of correlation between the pre- and postoperative tests for rotational nystagmus is .54 with a probable error of .08, and for the optokinetic tests .94 with a probable error of .02.

In summary, the changes in the patients receiving transorbital lobotomies were mixed and showed no significant shift in any way.

THERMOCOAGULATION. Records were obtained on both the patients receiving the thermic type of operation. The 4 tests obtained on the 2 patients showed only increases with an average percentage change of 107.8 per cent increase.

Data were obtained on 4 of the 6 tests (vertical counterclockwise and visual clockwise not obtained). There was an increase of 83.8 per cent if the averages of all the tests are considered. There was a total average increase of 80.0 per cent from pre- to postoperative and the average total percentage change was also 83.8 per cent.

The average preoperative mean on the rotational tests was 7.5 jerks per minute with an S.D. of 3.4. Postoperatively this increased to 13.6 jerks per minute with an S.D. of 6.2.

The coefficient of correlation between pre- and postoperative tests was obtained only for the rotational nystagmus where it was found to be .44 with a probable error of .18. There were insufficient data to obtain results on the optokinetic tests.

Review of the data obtained following thermocoagulation indicates a consistent increase in nystagmus but the number of cases is inadequate to draw reliable conclusions.

THALAMOTOMY. The data on these 2 cases were insufficient.

LATENT PERIOD. The data on the latent periods follow without exception the same trends as the overall rates of vestibular function and are apparently measures of the same function. The only datum of significance is the fact that, following venous ligation approximately twice as many patients show a reduction in the latent period postoperatively as compared with preoperatively. This compares directly with the same proportion of increase in rate of nystagmus pre- and postoperatively.

.01 per cent. The average increase was 108 per cent in contrast to the average decrease of 3.4 per cent giving a difference of 102.5 per cent increase.

When the averages of the 6 types of tests for all the patients are considered, 4 of them show increases only, one patient shows one decrease of .1 per cent in contrast to 3 increases averaging 68.2 per cent. Another patient shows equal increases and decreases. On the 18 tests, 15 were increases with an average of 161.2 per cent increase for the 6 types of tests. The 3 decreases averaged 3.4 per cent for the 6 tests. The resultant difference is 157.8 per cent.

The total average of postoperative tests is 93 per cent greater than the preoperative tests. The total average change is an increase of 137.6 per cent.

The average of all preoperative rotational records is 9.4 jerks per minute with an S.D. of 5.4. This increases postoperatively to 13.5 with an S.D. of 7.4. On the optokinetic tests, the shift is from 5.5 jerks a minute with an S.D. of 3.7 to a rate of 17.2 jerks per minute with an S.D. of 11.5.

The coefficient of correlation between the pre- and postoperative tests is .47 with a probable error of .08 on the rotational tests and .31 with a probable error of .20 on the optokinetic tests.

In summary, it appears evident that there is a marked increase in nystagmus on the rotational tests following the venolysis operation and the increase is even greater for optokinetic nystagmus.

TRANSORBITAL LOBOTOMIES. Of the 9 patients receiving transorbital lobotomies, one patient (A10) had been operated on during the first Columbia-Greystone project and was not included in our group. On 6 of the remaining 8 patients, at least one adequate record on one test was obtained both pre- and postoperatively. Patient B21 had only one test with adequate records and both pre- and postoperatively showed minimal amounts of nystagmus. Due to the rigidity of statistical manipulations her record indicates a 200 per cent increase, although the change was only from a rate of 1.1 jerks per minute to 3.3 jerks per minute. The calculation was therefore done both with and without her record included.

On 2 of the 6 patients, there was a decrease only, while on one patient (B21) there was an increase only. On the remaining 3 patients there were both increases and decreases. The 5 increases averaged 84.6 per cent for the 6 tests and the 11 decreases averaged 19.3 per cent.

Three of the patients showed an average total percentage decrease and 3 showed an increase. The total average percentage change was an increase of 48.3 per cent. With the elimination of B21, this changes to a decrease of 4.6 per cent.

On the 6 individual tests, 1 showed a decrease only, another an increase only, and the remaining 4 were mixed. The difference between

the average increase and decrease is plus 58.1 per cent, which is considerably reduced with the elimination of B21. The difference between the total averages is a decrease of 4.5 per cent and the total average percentage change is an increase of 3.7.

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Discussion

The fact that acclimation occurs, although it does not reach a level of statistical significance, is not entirely unexpected. Since all tests were given with the same waiting period between different parts of the test, this does not interfere with intergroup comparisons. It would seem desirable, however, to experiment with different periods of time between the subtests and if a wait of an additional few minutes would nullify the effects of previous stimulation, the technique should be modified to include this change in procedure.

Whether there is masking of increased vestibular function in the horizontal position, due to the previous test in the vertical position, has not been clearly disproved. It might well be advisable, on subsequent tests, to vary the order of procedure so that in a certain percentage of the cases the horizontal position is tested prior to the vertical one.

It has generally been supposed that visual stimuli are not as strong an inductant of nystagmus as rotation. The evidence for this has been made by comparing different groups of subjects and it is believed that this is the first time that the same group of subjects was subjected to fixed acceleratory stimulus in both the rotatory and visual fields. Review of data obtained in the first Columbia-Greystone project seemed to indicate that there is a summative effect when optokinetic and rotational nystagmus are combined. The degree of summation is something that could bear investigating and would be necessary for a complete understanding of the nature of nystagmus.

The only clearly demonstrated change after operation is that nystagmus is increased following venous ligation or thermocoagulation. In all probability, there is some loss of cortical inhibition but the influence of postoperative edema cannot be conclusively ruled out, although the fact that the change persists even after several months (data not included) would seem to indicate that there was a real loss of inhibition. The only other group of operated cases on which adequate data were obtained are the transorbital group and the nature of the operation in this case is such that there would be considerably less edema. The fact that the data on the latent periods also indicate increase of reaction after venous ligation is exactly what might be expected.

In the first Columbia-Greystone project there appeared to be a correlation between the amount of cerebral cortex removed and increase of vestibular function. This would not be in disagreement with the present findings but since no tissue was removed in the present study, a definite correlation cannot be made.

In summary, therefore, the present data would seem to indicate that the cerebral cortex does exact some inhibitory function over the vestibular response. This influence is more pronounced upon the optokinetic type of nystagmus produced by rotation of the visual field.

Although the conclusion is not final, there is some slight evidence at least that vestibular function may be increased in schizophrenia

rather than decreased, as has been popularly supposed. Considerably more investigation is necessary before this conclusion can be verified.

It was impossible to determine whether "physiologic reactivity," as measured by nystagmus response, could be correlated with either prognosis or improvement because of the limited range of improvement.

AUTOKINESIS

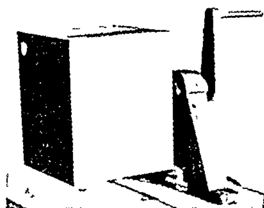
The term autokinesis is applied in the present study, to the apparent spontaneous movement of a stationary point of light in a darkened room.

"While upon a mountain peak 10,700 feet above the level of the sea during the course of some investigations in Teneriffe, Humboldt saw the stars moving about in a most bewildering way. This phenomenon was visible either with a telescope or with the naked eye. After lasting for some 7 or 8 minutes, it ceased and soon the sun appeared above the horizon... Humboldt gave the name 'Sternschwanken' to his discovery. Under this name it was frequently mentioned in the astronomical literature of the next half century." (Adams, '12.)

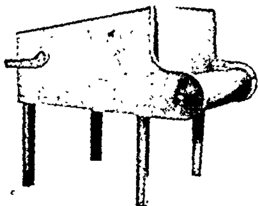
With this observation 150 years ago, the history of what has come to be known as the autokinetic phenomenon has its enigmatic beginning. Apparently the phenomenon did not come to general attention until it was republished about 1850. The original description was in 2 letters sent to Von Zach dated Cumaná, September 1st and November 17th, 1799.

Schweitzer (1858) demonstrated that the stars did not actually move by having different observers report on such apparent movement simultaneously. He found that the reports of the observers disagreed to such an extent that there was little question but that the movement was apparent rather than real.

The first really extensive piece of research on the subject was done by Exner (1896). He offered the explanation that the phenomenon is caused by muscle strain. Charpentier (1886) rejected unconscious eye movements and muscle tensions as the cause of the phenomenon. His own hypothesis was that "thoughts of moving the object or thinking of various directions initiates the motor act" (liberal translation by the author). In the same year, de Parville (1886) pointed out the similarity of Charpentier's findings to those of Von Humboldt and Schweitzer. Charpentier later replied to de Parville asserting the belief that the phenomenon which he (Charpentier) had described—the production of apparent movement by the use of a faint light in a dark room—was qualitatively different from the illusions described by Von Humboldt, Schweitzer, 1858 and Hoppe (1879). (Entirely independently Aubert (1887) had reported the same illusion with the light in the dark room and it was he who named the phenomenon "autokinetische Empfindung.") Charpentier agreed that the phenomena of star "movement" or the apparent motion of a black spot on a white background described by







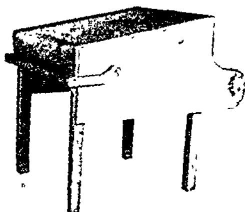


Plate IV; A. Box for holding light source. B. Rotation of box containing light source. C. Table for recording apparent direction of autokinesis. D. Cutter at end of table.

Hoppe were due to eye movements. Hoppe had pointed out that the autokinetic movement (produced with the faint light) was toward the source of a sudden sound and accounted for it on a reflex basis. Charpentier believed that it was the "thought of the direction of the noise which determines the movement."

Bourdon ('02) in line with his countryman, also discounted eye strain or muscle movement as the source of the phenomenon. He believed it was caused by the "impulse of the eye to motion." Fleischl (1892) had offered an explanation in terms of "changes in the pigment epithelium behind the cones." Helmholtz (1886-94) accounted for it as "due to the construction of the retina." Klein ('04-'05) accounted for the phenomenon on the basis of "vacillation of light preserved by the retina."

Ferree ('08) offered an explanation of similar illusions on the basis of what he described as "the streaming phenomenon." He described retinal currents which, to him, offered a logical explanation for these illusions. Two years later, Edridge-Green ('10) disputed Ferree's conclusion since he described cases in which the "streaming" itself would have been blocked but the illusions still occurred. Rollett ('11-'12) returned to the streaming phenomenon and discounted the work of Carr ('10) who had listed 4 factors: (1) Position of the eye in the socket, (2) after effects of eye position, (3) motor strains, and (4) after effects of such strains.

Adams ('12) reaffirmed this work of Carr. Schilder ('29) in a lengthy article, reviewed the entire history and expressed general agreement with Exner. He offers some very acute psychologic observations which are compatible with the physiologic approach. He feels that the movement is caused by eye strain ("alertness strain") in attempting to hold the object on the fovea centralis. In 1914 Hunter ('14) also disputed the streaming theory and listed: (1) Eye muscle strain, (2) retinal changes, and (3) association factors, as causes of the illusion. He found that abrupt movements of the head or eyes, which should cause changes in the direction of the "streaming," did not change the autokinetic movements in the expected manner.

In 1928 Guilford and Dallenbach ('28) again, subscribed to a "streaming phenomenon" as the responsible factor and attempted to prove that eye movements were not sufficient to account for the phenomenon. They took moving picture photographs of eye movements and found that neither the extent nor direction of the eye movements could account for the apparent movement. Kleint ('38) reviewed the subject in 1938 and in 1941 Voth ('41) began his work with the relationship of the autokinetic movements to mental disease. He accounted for individual differences with the explanation that "nervous impulses travel at different speeds in different individuals." He referred to an article of Benedek and Angyal pointing out the close relationship between conceptual and perceptual content, particularly in the optic field. In 1947 he reported (Voth, '47) his results on a large series of patients studied

at the Menninger Clinic and the Topeka State Hospital. He offered no explanation of the origin of the phenomenon but stressed description and differences in different types of psychiatric conditions. He made a distinct advance in attempting to create a formula whereby autokinetic function can be reliably measured. Our own attempts to use Voth's indices proved extremely difficult since he holds that "stops" are the inverse of motion and our patients could not reliably report or record their "stops." On the basis of Voth's approach, we have devised our own formula which will be discussed subsequently.

Apparatus

A special light box was constructed which uses ordinary 60-cycle alternating current and which gives a constant stimulus. The box is completely light proof except for a small pin hole in the upper right hand corner (see Plate IV A). The source of light is not in direct line with the bulb, which helps to eliminate any differences which might be caused by observation from slightly different positions. The box contains a 25-watt bulb and the switch is naturally outside the box. In the first Columbia-Greystone project, no test was made of the patient's response to drawing a light that was circled through a diameter of known dimensions. Review of Thurstone's ('44) book clearly indicates the value of determining the "scale of reference" on which the drawing is made. Therefore, the present apparatus is constructed so that the entire box can be revolved through a circle of known diameter by means of a handle at the back. (See Plate IV B.)

The only other special equipment needed was a recording table which was built at a height comfortable for drawing when the subject is seated. The writing surface is inclined at an angle designed to prevent, as far as possible, distortions that might arise by drawing in a projected plane. A large roll of ordinary wrapping paper (see Plate IV C) can be directly attached to the table and run over the writing surface. A metal cutting edge is so placed that the record can be easily torn off when completed with the next record sheet automatically sliding into place (see Plate IV D).

It is essential that the test be administered in a room which can be completely darkened, in order to hold conditions of the test constant. An interval timer is also needed so that there is some method of exact timing while the lights are out. A stopwatch is also provided in order to note, by pressing in complete darkness and later examining, when the subject first reports seeing movement.

In determining the length of the lines drawn, a map measurer is found to be the most convenient instrument. Simply by following the course of the line with the revolving edge of the map measurer, the total distance can be read directly from the dial of the measuring instrument.

Method

The subject is brought into the test room while the lights are still on. The light box, however, is concealed behind a curtain in order to prevent the nature of the apparatus from influencing the subject's impressions of the nature of the light movement. The subject is seated in one corner of the room at the recording table and the light box is placed on another table at eye level, approximately 15 feet away from the front of the recording table.

An "X" is placed by the experimenter in the center of the record sheet which occupies the entire writing surface of the table. A pencil is then placed in the subject's hand in an ordinary writing position with the point resting on the center of the "X." No explanation of what to expect is given so that the subject's reactions will be influenced as little as possible. The experimenter than proceeds to the other end of the room, turns off the room lights and turns on the light box, allowing the curtain to fall. This procedure ordinarily occupies at least 3 or 4 minutes so that any ordinary stimulation caused by walking to the table, or getting seated, has worn off.

Previous testing has shown that allowing time for dark adaptation does not materially alter the results. Some of the subjects find that sitting in complete darkness is quite discomforting and since results were shown to be the same, no period of dark adaptation is used.

As soon as the room has been darkened, the subject is instructed to "describe what you see." Except in very rare instances, the usual object seen is "a small light." The color of the light may be described spontaneously at this point. Sometimes slight adjustments in the angle of the box are necessary before the subject sees the light source.

As soon as the light has been reported as being visible, the subject is instructed "tell me anything at all that happens to the light." Care is taken in the wording of instructions so that no suggestion of movement is given and instructions are identical, insofar as is possible, for each subject.

Immediately prior to turning out the lights, the interval timer is set for 5 minutes so that a bell will ring at the end of the test period. In addition, when the lights are turned out, a stopwatch is started and as soon as the subject reports movement of the light (if he does report such movement) the watch is stopped and can later be read to determine the exact number of seconds elapsing before movement was observed.

The source of light remains stationary throughout the entire 5 minutes. When the light appears to move, however, and the subject reports it as moving, he is then told "draw on the paper the distance and direction in which the light moves. In other words, try to follow the light exactly as it is moving."

If the subject notes that the light appears to stop (care is taken not to suggest that this will occur) he is instructed to place a circle at this point and to continue drawing if the light should move again. Occasionally, a subject will move the pencil off the writing surface in

the course of following the apparent movement. Then, and only then, is he asked to bring the pencil back to approximately the center of the paper and continue as before. Conversation that might influence or distract the subject is kept to a minimum.

When the bell rings at the end of 5 minutes, the room is kept in darkness and the curtain reapplied in front of the light box. The subject is first asked whether he saw any movement, if it was not reported spontaneously. If the movement is reported, he is asked to estimate the total distance which the light moved since he first saw it "if the movement were stretched out in a straight line." The subject is next asked to estimate what part of the time the light was in motion. He is also asked to report on whether the light seemed to move "slow, medium, or fast." If the color of the light has not been spontaneously reported, the subject is requested for this information. He is also asked whether there was any movement in a forward or backward direction.

After this information has been collected, the subject is given a pencil with red lead instead of the black-leaded one he has been using up to this point. The lights are turned off again and the experimenter drops the curtain from in front of the light box and this time immediately begins turning the handle at a fixed rate until the source of light has made one complete revolution. The box is so constructed that the circle has an 8-inch diameter. Prior to turning the handle, the subject is this time instructed to draw the movement of the light. When this has been completed the lights are turned on.

SCORING. The total distance of the autokinetic drawing is measured as is the maximum breadth of the figure drawn. The number of times direction is reversed, the number of times the drawing goes off the paper, and the data obtained in response to the questions are noted on the subject's record. The total distance that is drawn in response to the stimulus circle is also measured, as is the maximum breadth of the stimulus circle. Finally, the pattern of both the autokinetic movement and the stimulus circle are scored and placed in one of the following categories: (a) No movement, (b) unidirectional, (c) unidirectional with one reversal, (d) circular, (e) zig-zag, (f) multiple patterns, or (g) nondescript. At times there are superimpositions of one pattern upon the other, or a combination of patterns is used.

Since a multiplicity of data is collected, experimentation was carried out over a period of many months to determine what was the most suitable method of reducing the information to usable and simple form. The formula used by Voth had previously been rejected for reasons already detailed. The final conclusion was that the following factors are the ones of major importance:

1. The total distance drawn in following the autokinetic light stimulus.

2. The length of time during which the stimulus autokinetic light is exposed.

3. The length of time during which movement appears to take place.

4. The relative scale on which the figure is drawn. (This can be determined by the total distance of the line drawn in response to the stimulus circle where the actual diameter of movement is known.)

The following formula was evolved as being the closest approximation to an actual measurement of autokinetic function:

$$\frac{\text{No. of seconds observation (300)} \times \text{total distance of recorded autokinetic movement}}{\text{No. of seconds apparent movement} \times \text{total distance drawn for stimulus circle}}$$

Results

Typical records are presented in figure 38. Here the smaller of the 2 patterns below is in response to the stimulus circle and, on the actual record, appears in red, which prevents any possible confusion.

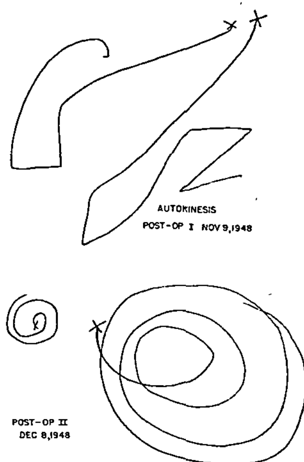


FIG. 38. Typical records of autokinesis.

TOTAL DISTANCE. In the first Columbia-Greystone project the average total distance drawn by 100 employees of the Veterans Administration, Lyons, New Jersey, was compared with the postoperative data obtained in this previous study. In addition, the data on these 100 patients were compared with a high degree of agreement with Thurstone's findings ('45) on 186 subjects. In the present study, there was an opportunity to test all 30 schizophrenic patients 3 times preoperatively and the results on these 90 tests are compared graphically with both Thurstone's data and that of the non-psychotic control subjects, in the first Columbia-Greystone project (see fig. 39). It should be noted that Thurstone's test was of only 2 minutes duration; whereas, on both the non-psychotic controls and the present 90 tests on the 30 schizophrenics, the test period was of 5 minutes duration each. In order to equate the data, it was therefore necessary to reduce by two-fifths the total distance on data other than Thurstone's.

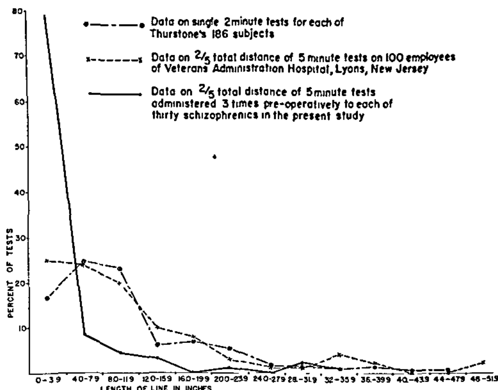


FIG. 39. Percentile distribution of total distances of lines drawn in following autokinetic movements.

The schizophrenic test results show quite a striking difference from that of the non-psychotic controls. In 51.1 per cent there is no evidence of perceived movement and in another 27.8 per cent there is minimal movement. This gives a combined total of 78.9 per cent, with little or no movement as compared to 16.7 per cent of Thurstone's tests and 25 per cent of a Lyons' group. Even when the tests where no motion is observed are subtracted from the schizophrenic group, there is still appreciably less movement reported. In addition, in

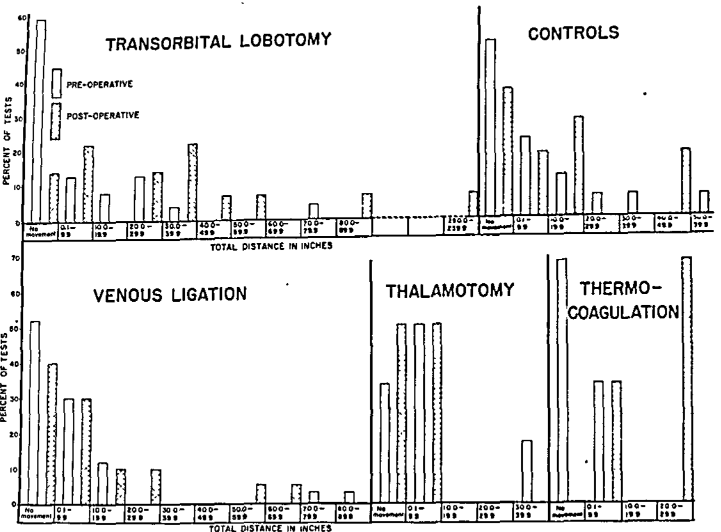


FIG. 40. Total distances of autokinetic movements in patients before and after the various operative procedures and among the controls.

this preoperative group of 90 tests, the greatest amount of recorded movement was less than 36 inches (using the same scale as Thurstone's subjects were tested on), whereas, in the Lyons' group, some of the records were greater than 48 inches and in Thurstone's group greater than 44 inches.

Ligation of the Cerebral Veins. Those patients on whom ligation of the veins was performed are compared pre- and postoperatively in figure 40. Although there is a slight increase of total distance drawn, in some of the categories, 40 per cent of the tests still show no movement postoperatively and 2 of the preoperative tests show greater distances drawn than any of the postoperative ones. The changes of distance which do occur do not appear to be significant. The distance for the total 5 minutes is used instead of two fifths of the distance. The data remain unconverted, however, for convenience with comparing data with that recorded in figure 39. (e.g. Two fifths of the 10.0-19.9 group would be the same as the 4-7.9 group in figure 39, so that conversions are easily made.)

Transorbital Lobotomy. The only test results showing a marked shift pre- to postoperatively are in those patients who received transorbital lobotomies. Prior to operation, almost 60 per cent of the tests in this group (see fig. 40) show no movement; whereas, less than 15 per cent are motionless after operation. Throughout, there is an increase of movement in practically all categories. Preoperatively only 4 per cent of the tests show a total distance of 40 inches or more; whereas, postoperatively, there are more than 25 per cent of the records with at least this total distance drawn. Other indications that the most marked changes occur in this group are indicated later in this paper.

Thalamotomy. The number of tests are small in this group and, if anything, indicate a decrease of movement postoperatively but not to such a degree as to be of statistical significance. (See fig. 40.)

Thermocoagulation. As can be seen from figure 40, there is a persistent increase of movement postoperatively. Four of the 6 tests showed no motion prior to operation but all of them show movement postoperatively. The total number of patients operated on is so small that the results can only be termed "suggestive."

Controls. Although there is some slight indication of increase of total distance drawn, the changes in the control group are too small to be of any importance. The comparability of the "preoperative" and "postoperative" findings presents substantiating evidence that test conditions remained relatively constant and that ordinary variability of responses is within limits that would

make the postoperative changes significant where they occur. (See fig. 40.)

FORMULA SCORES. Using the weighted formula previously described, which seems to be the best measure of autokinetic function, the group of patients receiving transorbital lobotomies show a marked difference from the other 4 groups.

LIGATION of CEREBRAL VEINS

PT NO	PRE-OP	POST-OP
B-1	0	0
B-2	0	770
B-3	0	0
B-4	(264)	–
B-5	259	228
B-6	0	0.65
B-7	568	0
B-8	1299	628
B-9	0	264
B-10A	652	702
B-11	026	212
B-12	653	074
AVERAGE	314	2.68

THALAMOTOMY

PT NO	PRE-OP	POST-OP
B-13	173	216
B-14	186	0
AVERAGE	180	108

THERMOCOAGULATION

PT NO	PRE-OP	POST-OP
B-15	0	938
B-16	02	183
AVERAGE	.01	561

TRANSORBITAL LOBOTOMY

PT NO	PRE-OP.	POST-OP.
B-17	703	2276
B-18	5.00	0.38
B-19	0	0
B-20	3.77	2 06
B-21	1.18	1376
B-22A	0	170
B-23	349	803
B-28	167	798
AVERAGE	2.43	7.08

CONTROLS

PT NO	PRE-OP	POST-OP
B-10	2.97	6.05
B-22	079	0
B-24	046	474
B-25	171	0.90
B-26	0	0
B-27	679	067
AVERAGE	2.12	2.06

FIG. 41. Average formula scores for different operative groups and controls.

Ligation of Cerebral Veins. The 3 preoperative tests and the 2 postoperative tests are each averaged separately and the average formula score for each patient in this group presented in figure 41. Patient B4 is not included in the average of the preoperative tests since no postoperative score was available for her, due to her death.

Two of the records show no change between pre- and postoperative condition, both indicating that no motion was observed. Three of the patients show decreases and 6 show increases. The decreases were all greater than 50 per cent. The difference between the pre- and postoperative average for the 11 patients, on whom complete records were obtained, is not significant. There is a slight decrease postoperatively in the total average formula score.

Transorbital Lobotomy. One patient in this group continued to show no evidence of any autokinetic movement after operation and 2 of the patients show decreases. In the remaining 5 patients, there are quite marked increases postoperatively and the difference between the average preoperative and the average

postoperative formula score shows a significant increase. These data are presented in figure 41.

Thalamotomy. The average formula score, both pre- and postoperatively, is quite low for both these patients and difference between the total average is not significant (see fig. 41).

Thermocoagulation. Here, as in measurement of total distance drawn, the difference between the preoperative and postoperative formula score would be extremely significant if the total number of cases were larger. Results are suggestive that a real change may be occurring (see fig. 41).

Controls. The 6 patients tested in the control group have such formula scores (see fig. 41) that there appears to be no difference pre- and postoperatively when the group is considered as a whole. Three of the patients show decreases, 2 show increases, and one remains unchanged.

SUBJECTIVE MOVEMENT. Not only does movement actually increase in the group of patients receiving transorbital lobotomies but, subjectively, there is also an increase. In figure 42, the per cent of time that the subject thought that the light was in motion and the estimated distance that the light appeared to move is recorded for each of these 8 patients. Six of the 8 patients show an increase in their estimation of the percentage time the light was in motion; one shows no change in his estimate (0 before and after) and one shows a very slight average decrease.

	Per cent of Time in Motion		Distance in Inches	
Pt No	Pre-Op	Post-Op	Pre-Op	Post-Op
	0		0	
B-23	60	67	54	144
	70	67	108	36
	0	100	0	36
B-28	0	100	0	24
	100		3	
	0	?	0	4 miles
B-17	20	100	2	300 feet
	100		24	
	0	0	0	0
B-18	0	50	0	3
	?		10	
	0		0	
B-19	0	0	0	0
	0		0	
	1	100	144	1499 miles
B-20	100	2	1	1/8 inch
	100		144	
	0	67	0	1/2 mile
B-21	100	95	240	5000
	?		1/2	
	0	75	0	35,000 miles
B-22A	0	75	0	36
	0		0	

FIG. 42. Pre- and postoperative estimated time and estimated distance autokinetic light moved for patients receiving transorbital lobotomy.

Also, 6 of the 8 patients in this group receiving transorbital lobotomies show increases from pre- to postoperatively in their estimate of the distance that the autokinetic light moves. One patient, subjected to ligation of the cerebral veins estimated preoperatively that the light moved 35 billion miles and reduced this a few billion postoperatively. Although some of the estimates made in figure 42 are sizeable, no other is quite this extreme; the greatest estimate being a mere 35,000 miles. Non-psychotic subjects have estimated up to 5 miles, so that only 2 of the reports in this transorbital group need necessarily be considered "excessive."

In the 6 patients who estimate a greater distance postoperatively, it appears quite significant that the greater of the 2 postoperative estimates was always the first one. In other words, immediately after operation, the light appears to move with considerable rapidity and upon retest, approximately 2 months later, in each of these 6 cases, the movement has subjectively decreased.

It is interesting to note that despite the more conservative estimate on the second postoperative test, the lines actually drawn in following the autokinetic light are of somewhat greater length than those drawn on the first postoperative test, when subjective movement appeared so excessive.

In none of the other 3 operative groups, nor in the control group, are there statistically significant changes in estimation of distance and the data are therefore not presented here.

STIMULUS CIRCLE RESPONSE. Since the stimulus circle which the patients were asked to draw was of the same order of magnitude as that used by Thurstone on 188 subjects, a comparison of data is of considerable interest. The mode of Thurstone's group was a drawn diameter between 2 and 3 inches. The mode for 90 tests on the 30 schizophrenic subjects preoperatively was no movement at all. If the 24.4 per cent of the tests showing no movement is disregarded, the mode then falls between 1 and 2 inches. The means for Thurstone's tests is 3.48 inches and for the schizophrenics 2.32 inches. These diameters in the schizophrenic tests should actually be reduced even more, since the breadth of many is considerably increased by an artifact. About one quarter of the schizophrenic tests resulted in the patients drawing straight lines, although they were clearly presented with the light moving in a circle. Since "diameter" was measured as the greatest distance between any 2 points on the record, this gives an artificially large score. A more comparable method of measurement would be to multiply all of Thurstone's data by π to obtain the total distance drawn and compare this with the total distance drawn on the schizophrenic tests. This was not felt necessary since the conclusion can be drawn even with the artificially large diameters of the schizophrenic group that observed real motion, when recorded, is considerably less in schizophrenics than in normals. These data are graphically presented in figure 43.

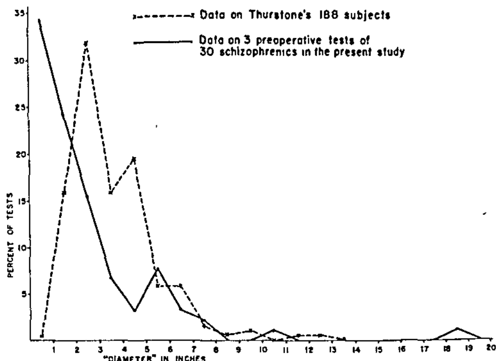


FIG. 43. "Diameters" drawn in response to fixed stimulus circle.

As noted previously, 24.4 per cent of the schizophrenic tests resulted in no drawing whatsoever. Only 27.8 per cent show actual circles or near-circles. In 13.3 per cent the figures resemble semicircles and 3.3 per cent of the records show multiple circles, usually 3 or 4. The remaining 31.2 per cent of the records are primarily straight lines but included also zig-zags, squares, and a few nondescript patterns. Since this is the largest group, the data were carefully gone over to try to determine the source of these other patterns. It was noted that in many cases, the pattern drawn in response to the stimulus circle of light resembled the previous autokinetic pattern rather than the actual circle pattern made by the moving point of light. Figure 38 illustrates this tendency quite remarkably.

COLOR OF LIGHT: An unexpected finding in the first Columbia-Greystone project was the fact that although the light source was an ordinary electric light bulb, a veritable spectrum of colors was named in describing the light. In figure 44, the data obtained on the 100 non-psychotic controls are included for comparison with the present group of patients.

Of the 100 non-psychotic controls, 75 per cent saw either white, silver, or yellow, 16 per cent saw orange or red, and the remaining 9 per cent saw assorted colors. In the 90 preoperative tests on the schizophrenics, the 3 expected colors (white, silver, or yellow) make up only 53.3 per cent of the total, the orange and red are more than twice as frequent as in the non-psychotic control group (34.4 per cent)

OBSERVED COLORS

		White	Silver	Yellow	Orange	Red	Blue	Green	Changeable	Brown
NON-PSYCHOTIC CONTROLS (100)		35	3	37	7	9	4	1	4	0
VENOUS LIGATION	PRE-OP.	8	3	13	4	6	1		1	
	POST-OP	4	2	8		4				
TRANS-ORBITAL	PRE-OP	2		8		10		3	1	
	POST-OP			6	2	7				
THERMOCOAGULATION	PRE-OP			4	2					
	POST-OP			3						
THALAMIC	PRE-OP	1			3				2	
	POST-OP	1				1				
CONTROLS	"PRE-OP"			9	3	3	1		1	1
	"POST-OP"	1		4		2			2	1
TOTAL SCHIZOPHRENIC 90 PRE-OP TESTS		11	3	34	12	19	2	3	6	1

FIG. 44. Colors reported for autokinetic light.

and the remaining 12.3 per cent are assorted colors, with one extraordinary "brown" reported. The color shifts from the pre- to the postoperative groups are unremarkable and slight.

A more accurate method of analysis is to deal with those patients who show consistency in designating the color of the light. These data are presented in figure 45, where, with the exception of the non-operated patient controls, one half to two thirds of the patients consistently named the same color. Since only 2 patients received thalamotomy and 2 thermocoagulation information on the effects of these

	Venous ligation	Thalamic	Thermo-coagulation	Transorbital	Controls
1 CONSISTENTLY the SAME COLOR PRE-OPERATIVELY	66.7%	50%	50%	62.5%	16.5%
a REMAINING CONSISTENTLY the SAME COLOR POST-OPERATIVELY	42.9%	0%	100%	20%	100%
b NEARLY CONSISTENTLY the SAME COLOR POST-OPERATIVELY PLUS THOSE CONSISTENTLY the SAME COLOR	85.7%	100%	100%	20%	100%
c NOT AT ALL CONSISTENT POST-OPERATIVELY	14.3%	0%	0%	80%	0%
2 CONSISTENTLY the SAME COLOR PLUS THOSE NEARLY CONSISTENT PRE-OPERATIVELY	75.0%	100%	100%	62.5%	66.7%
a REMAINING NEARLY CONSISTENT or CONSISTENT	87.5%	100%	100%	20%	75%
b NOT AT ALL CONSTANT	12.5%	0%	0%	80%	25%
3. NOT AT ALL CONSISTENT PRE-OPERATIVELY	25.0%	0%	0%	37.5%	33.3%

FIG. 45. Relation of nature of color reports to nature of operation.

procedures is limited. However, following venous ligation 42.9 per cent who had consistently named one color preoperatively, continued to name this same color postoperatively. In contrast, only 20 per cent of the transorbital group continued with the same color.

It appeared legitimate to include an evaluation of those patients in whom the color was nearly consistent (e.g., orange on one preoperative test and orange-red on the other 2 tests). Here, over 60 per cent

of the patients showed consistency in all groups in naming the same, or nearly the same color, preoperatively. Postoperatively, at least 75 per cent of the patients continued the same color series, with the exception of those patients receiving transorbital lobotomies. Here, in marked contrast to the other 4 groups, 80 per cent of the patients described a change of color.

PATTERNS OF AUTOKINETIC DRAWINGS. The most striking comparison between test results on the 100 non-psychotic controls obtained for the first Columbia-Greystone project and the 90 preoperative tests of the 30 schizophrenics in this project is in the category of "no movement." Whereas, only 2 per cent of the non-psychotic controls fail to observe at least some autokinetic movement, over one half of the schizophrenic tests show no movement (51.1 per cent). It is felt that a simple unidirectional pattern is at a lower level of organization than circular, zig-zag, or even unidirectional lines with one reversal. As can be seen in figure 46, 20 per cent of the non-psychotic controls show such a simple unidirectional pattern as opposed to 25.6 per cent (23 tests) of the 90 preoperative schizophrenic test patterns. If the 51.1 per cent of the tests showing no movement are temporarily discounted, this means that of those patients showing motion, more than half show the least complex type of pattern. If the 2 non-psychotic controls showing no movement are discounted, there are still less than one quarter of these control patients showing this least complex type of pattern.

		No Movement	UNDIRECTIONAL Simple	UNDIRECTIONAL With one Reversal	Circular	Zigzag	Multiple Patterns	Non-descript
NON-PSYCHOTIC CONTROLS		2	20	15	34	14	13	2
VENOUS LIGATION	PRE-OP	17	13			3		3
	POST-OP	7	4	2	2	2	2	
TRANS-ORBITALS	PRE-OP	13	2	6	2	1		
	POST-OP	2	2		4	4	1	
THALAMIC	PRE-OP	2	2	2				
	POST-OP	1	1					
THERMOCO-AGULATION	PRE-OP	4	1	1				
	POST-OP		1	2	1			
CONTROLS	"PRE-OP"	9	5		2		2	
	"POST-OP"	3	2		1	4		
ALL 90 TESTS ON PREOPERATIVE SCHIZOPHRENICS		45	23	9	4	4	2	3

FIG. 46. Reported patterns of autokinetic movements.

Approximately half of the non-psychotic control patients show circular or zig-zag patterns in contrast to less than 10 per cent of the schizophrenic tests. In addition, 13 per cent of the non-psychotic controls showed multiple patterns in contrast to about 2 per cent of the schizophrenic records.

In the group of patients given the venolysis operation, there was a slight increase in complexity of the pattern postoperatively. The most marked shift in the direction of increasing complexity of pattern was, as might be expected from the other data, in those patients receiving transorbital lobotomies. Preoperatively 12.5 per cent of the patterns are in the circular, zig-zag, or multiple pattern groups. After operation, 69.2 per cent of the tests are in this group of "complex patterns."

The thalamic group show no appreciable change and the thermic group show only a slight increase in complexity of pattern, although none of the tests in this latter group are in the "no movement" category postoperatively. There was an unaccountable shift in the control group as well, since 22 per cent are in the circular-zig-zag-multiple pattern group preoperatively and 50 per cent postoperatively. The shift in the transorbital group, therefore, may be of slightly less significance than it at first appears. However, the increase in the transorbital group is more than five times that of the control group so that it is still probable that the shift in the transorbital group is of real significance.

Discussion

Although the basic nature of the autokinetic phenomenon remains unknown, it nevertheless appears to be a valuable instrument in the testing of psychiatric patients on at least 4 counts:

1. Since the field in which movement is produced is almost completely unstructured, the complexity with which the patient organizes it (i.e., the nature of the autokinetic pattern) may provide some measure of ability in this respect.

2. There are no adequate tests for measuring a patient's "productivity" and it may be that the total distance of the line drawn in response to autokinetic stimulus gives at least an approximation of this function.

3. The close relationship between conceptual and perceptual content has been noted by others and it is quite possible to entertain the hypothesis that the perceptual field is just as severely disturbed in mental disease as is the conceptual field. The response to the stimulus circle may provide some measure of this distortion.

4. Lack of autokinetic movement may provide a rough indication of failure of "responsiveness" to external stimuli.

LOW "ORGANIZATIONAL" CAPACITY. The relative "simplicity" of the patterns drawn may indicate that even if response is made to perceptual stimuli, it is of a minimal type. The perseveration of repeating the autokinetic pattern in the face of a very real stimulus of an entirely different configuration seems of great value in understanding

schizophrenic thought processes. The circular, repetitive nature of schizophrenic thinking makes it possible for these patients to draw a straight line, which has been perceived as the autokinetic pattern, even when a circle is objectively presented. The ability to "organize" is notably reduced in many schizophrenics, particularly in hebephrenics who constitute the majority of the present group of patients. Even when there are "systematized delusions" the organization of the material is very rigid, inflexible, and at an extremely "simple" (one-sided) level of complexity. The autokinetic pattern seems to provide some quantitative measure of this capacity.

REDUCTION OF "PRODUCTIVITY." The reduction of total distance drawn in response to autokinetic stimulation in the schizophrenics, as compared to the controls, has previously been demonstrated by Voth. His data contained this information but he makes no comment upon it. Psychophysiologically, this may indicate a lack of "productivity" which can be at least crudely quantified. There is some evidence that this indicates possible reduction in active cortical tissue. Teuber and Bender ('48) found reliably consistent reductions in "apparent motion" after cerebral lesions and it is possible to conceive that in schizophrenics there has been functional reduction in the amount of active cortical tissue.

"DISTORTION" OF REALITY. If the assumption is made that distortions in the perceptual field are even roughly proportionate to distortions in the conceptual field, the degree of failure in properly reproducing the stimulus circle may provide an index of the reality distortion. The hypothesis as to the interrelationship of these 2 fields is in need of considerable verification but such work as that of Benedek and Angyal is highly suggestive.

The physical distortions of the external world in schizophrenics is considerably greater than is generally realized. When specifically looked for in a series of patients admitted to the Veterans Administration Hospital, Lyons, New Jersey, it was discovered by Dr. Eugene Revitch and Nathan S. Kline, that almost all of them had fairly marked perceptual disturbances (e.g., "the floor seems to tilt," "objects look sort of wavy," "voices fade and get louder").

DECREASED "RESPONSIVENESS." The relative scantiness of distances drawn in response to the stimulus circle as compared with Thurstone's subjects may be a type of measure of failure in "responsiveness" of schizophrenic patients. Schilder has frequently pointed out (as have Kohler and others) that a perception invariably "calls for" a motor response. The relative quantifiable apathy of this response, as well as its distortion, may be of real importance in understanding the nature of the schizophrenic process. That this response is not altered by any of the operative procedures is not surprising, since none of the patients were really improved to any considerable extent

in the course of this project. It would be of extreme interest to test whether a change was in the direction of normality in patients who did improve. Even though we do not entirely agree with Voth's formula ('47), it is probably reliable enough to indicate that there is such a trend toward more typically "normal" responses in patients who do improve. The subjective "release" in the patients receiving transorbital lobotomies did not extend to the sphere which involved relationship with reality.

CHANGES FOLLOWING TRANSORBITAL LOBOTOMY: Although autokinetic tests were administered only postoperatively to the patients in the first project, the most striking feature observed was that the 7 patients after receiving prefrontal lobotomies showed no autokinetic movement whatsoever. Since they were not tested preoperatively, it is impossible to determine how much of a change occurred. In very marked contrast, the transorbital lobotomies produced a statistically reliable increase in amount of movement perceived. To attempt to explain this in terms of specific pathways involved would be sheerest conjecture at this point, but the evidence seems clear-cut that the prefrontal lobes have a direct bearing upon the autokinetic reaction. The failure of patients who had destruction of cortical tissue alone to show this response might indicate that the neurologic mechanisms involved were mediated by the more deeply placed association pathways.

The marked difference between the transorbital group and other groups, when the formula score is used, confirms this impression. Unfortunately, the number of patients receiving thermocoagulation is too few to satisfy statistical criteria as to the significance of the shift.

The marked increase in subjective movement immediately following operation in patients receiving transorbital lobotomies confirms the somewhat more objective evidence of the total distance drawn. Perhaps this subjective feeling of "release" is demonstrable in other spheres as well. Subsequently, there is some return of "inhibition" since the second postoperative estimate is consistently less than the first. The interesting fact that the total distance drawn increases at the same time as the subjective estimate decreases may be one illustration of the "ataxia" between the sphere of sensation or feeling and that of motor performance.

Explanation of the failure of consistency in color description in the transorbital group is puzzling. The initial color response is much less "objective" than in the control patients and it may be that the feeling of "release" encourages internal "freedom" in the perceiving of colors in contrast to the relative perseveration preoperatively.

Although no direct contribution is made to the question of origin of the autokinetic response, it does appear very probable as a result of the present study that the granular frontal cortex has a direct modifying influence upon perception of autokinetic movement.

Chapter 8

THE DESIGN OF THE PSYCHOLOGIC INVESTIGATION

Joseph Zubin

The basic problem of evaluating the psychologic changes accompanying frontal lobe operations probably will not be solved solely by psychologic methods. The cooperation of all the medical sciences as well as of the cognate basic sciences is essential for a solution of the fundamental problems which psychosurgery has raised. Within the field of psychology itself all the techniques that psychologists have evolved in their various specialties as well as those that they can borrow from adjacent fields must be mustered for the attack on this problem. The basic function of the psychologist doing research with psychosurgery patients may be described as the introduction of quantitative measures for the selection of patients who may benefit by the operation and for estimating changes in behavior following frontal lobe operations.

The changes brought about in the sensory, motor, and perceptual spheres by a brain operation can be readily measured with the tools and techniques of the psychophysiologist and the psychophysicist. It is important to bear in mind that psychosurgery patients are either psychotic or severely neurotic to begin with. The relative role of tissue removal in bringing about an improvement must be weighed against such factors as amelioration of psychotic processes, oscillation in psychoses, and even spontaneous improvement possibilities.

The selection and development of psychometric tests, interview techniques, and observational procedures are other areas which challenge the psychologist entering upon the evaluation of psychosurgery. Most of our present day techniques have been developed with normal persons. The usual testing of the psychotic and the severely neurotic patients with these procedures is primarily for diagnostic purposes. Tests of abnormal behavior itself must be adapted for each type of investigation. Even such simple materials as memory or perceptual tests, which have been developed with normal persons are not directly applicable to those who are abnormal. With the exception of a few standardized tests such as the Wechsler-Bellevue, all tests in the present battery were specially devised. The advantages of new methods are clear but they bring with them questions of standardization, reliability, and validity which are not easy to answer without a considerable amount of preliminary work.

The evaluation of the therapeutic outcome of psychosurgery presents a very difficult problem to the psychologist. The general effect of the "total push" to which all of the patients had been subjected also entered to confuse the issue. Furthermore, the role of the psychologic impact of the operation itself aside from the physiologic changes which it produces had to be considered. How much of the temporary or even permanent improvement is attributable to the psychologic expectancy or hope induced in the patient, in his family, and in the medical investigators? All of these factors needed scrutiny.

The relation of the preoperative personality of the patient and his attitudes towards the operation were important variables to be considered in the evaluation of outcome. Individuals with highly developed personalities and with capacities of a high order might possibly be altered by operation at a much greater cost to their capacities than patients whose initial level was low. In such cases it became important to weigh the eventual results against the expected losses. Patients who have very little to lose but whose well-being might be increased by operation present a different problem of psychologic evaluation than do patients whose initial capacity is high.

The statistical methods for evaluating the results of any method of therapy have heretofore depended largely on group methods in which the individuals undergoing the operation were regarded as a sample representing a given group of patients and the outcome of the operation was generalized for the whole group and each of its individual members. This procedure had many shortcomings when applied to the evaluation of brain-operated cases. The patients selected for operation were not a random sample representative of any patient population on a segment of such population. They were usually selected on the basis of availability and consent of relatives and absence of any physical contraindications to the surgical procedure. What generalizations can be drawn from a sample obtained in such an arbitrary manner, and how one can obtain satisfactory control group of patients remains an unresolved issue.

So far as the statistical methods of evaluation are concerned the observation of Von Mises ('47) is relevant. "It remains an invariable fact, dominating all problems in mathematical statistics, that no substantial inference can be drawn from a small number of observations if nothing is known 'a priori,' i.e., preliminary to the experiments about the object of experimentation."

Since some of the proposed operative surgical procedures were new, a repetition of some tests and techniques on the new variety of operations might lead to new findings. The ever-increasing crop of problems released by the wide-spread use of lobotomy, and of topectomy, as well as other varieties of brain operation was carefully sifted and the following procedures were selected: (1) psychometric functions, (2) complex mental functions, (3) attitude evaluation, (4) observational studies, and (5) psychophysiologic functions.

The psychometric procedures consisted of 2 intelligence tests

(Wechsler-Bellevue and the Porteus Maze) and 2 sorting and shift tests (Weigl and Homograph tests). The intelligence tests were selected in order to obtain a baseline for the preoperative intellectual level of the patients and to note whether any temporary or permanent changes occurred in intelligence. The sorting and shift tests were introduced in order to determine whether the new operative techniques produced a temporary decrement in performance on these tests.

The complex functions sampled in this investigation were memory, learning, maintenance of set, and perceptual functions. Some of these functions had been examined in the first Greystone project but the experimental procedures were modified so as to remove some of the difficulties which had been previously experienced. Other procedures had never been tried before with psychosurgery cases but were introduced because of claims and observations reported by other investigators.

Attitude evaluation (Anxiety and Complaint inventories) had been undertaken in the first Greystone project and led to the important conclusion that anxiety reduction seemed to be the most important underlying change resulting from brain surgery. In order to examine this hypothesis further, carefully constructed controlled interviews utilizing a standard interview technique of the type used by Kinsey et al., ('48) were prepared and applied to the patient group.

In the observational studies the patient was asked to wait in a prearranged room for his next appointment. During his 20-minute wait he was observed from behind a one-way screen and descriptive notes of his behavior were recorded. The responses of the patient while alone and when in company of another patient were contrasted preoperatively as well as postoperatively.

The psychophysiologic area sampled the functions of vision, audition, somesthesis, and kinesthesis. These functions which are among *those for which exact measurements by standard techniques were possible*, were investigated by the use of various tests to ascertain any reflections of brain operation in such spheres of behavior.

EXPERIMENTAL DESIGN

The experimental design for the psychologic techniques differed considerably from those ordinarily used in study of brain-operated patients. Until very recently only postoperative measures were available and inferences regarding possible deterioration or decrement in function were made on the basis of assumed preoperative functioning or by comparison with a more or less equated control group. Recent studies have introduced preoperative measures to serve as baselines for the postoperative results, viz., the first Greystone study. Here both preoperative and postoperative measures were available for the operated group as well as for a matched control group. Although the latter design was an improvement on its predeces

had several shortcomings. First, when a control group is matched with an operated group, the matching can be done only on the basis of a limited number of variables. For the majority of variables the groups remain unmatched. Consequently certain statistical devices must be utilized to remove initial inequalities in the operated and control groups. At times these statistical devices are adequate, but in some situations they are totally inadequate. Second, even on variables for which the 2 groups were matched, the intraindividual variability in behavior which is so characteristically different from patient to patient, remained uncontrolled. In order to circumvent these difficulties, it was decided to develop a new design in which each patient would serve as his own control. Two preoperative and 2 postoperative measures were obtained on most tests. The availability of 2 preoperative scores provided not only a more stable measure of level of performance, but it also gave an estimate of the range of intraindividual variability.

Because of limitations beyond the control of experimental design, the control group could not be adequately utilized. Too few cases were available, and the degree of correspondence between them and the operated group was not close. However, in several instances the availability of several preoperative measures on these controls provided a firmer basis for evaluating the outcome of the operation.

In order to identify the various testing procedures, the following system was devised. In referring to a given test, the number of days it preceded or followed the date of the operation was noted. Taking the operation day as day zero, preoperative testings were designated by a minus sign preceding the number of days before day zero, while letters following the numbers indicated the sequence of the test applications. Thus -60A means that it was the first application of the test (A) and that it was given 60 days before the operation, while +10C would mean the third application of the test (C) given 10 days after the operation.

SELECTION OF THE PATIENTS

Each of the patients who had been selected for the project was studied by each of the examiners with a view to determining the patient's capacity in the various psychologic tests. Test results were evaluated individually for each test performance of each patient. If the performance were not thought by the examiner to be a fair representation of the patient's ability, the particular test results were thrown out and a new attempt made to secure a representative performance. If such a satisfactory record could not be obtained, no record of the patient's ability on the test in question is given in the reports which follow.

The background data for the patients included in the psychologic reports which follow are given in Table 5.

Table 5

BACKGROUND DATA OF PATIENTS INCLUDED IN PSYCHOLOGIC REPORTS (COMPARE WITH FIGURE 6)

No. of Cases	Diagnosis C	H	P	M	F	Mean Age	Range of Age	Mean Years Hospitalized	Preoperative Mean IQ	Range IQ	Type of Surgery Employed
11	4	4	3	2	9	37.4	26-52	6.5	92.2	85-114	VL
7	0	7	0	2	5	31.1	27-34	5.6	70.6	55-60	TO
2	1	1	0	2	0	30.0	30-30	2.4	77.0	73-82	TC
2	0	2	0	0	2	29.0	32-26	6.5	77.0	58-96	TH
6	1	2	3	2	4	39.0	32-52	6.1	100.3	83-115	None
28	6	16	6	8	20	35.4	26-52	5.7	87.3	55-115	T

Legend:

VL = Venous ligation
TO = Transorbital lobotomy
TC = Thermocoagulation
TH = Thalamotomy
T = Entire group studied
C = Catatonia
H = Hebephrenia
P = Paranoia
M = Male
F = Female

It will be noted that the patients were primarily drawn from the fourth decade of life. Their preoperative IQ averaged 88. The average length of hospitalization was about 6 years. All of the patients were diagnosed as schizophrenia (usually hebephrenic schizophrenia).

Since it was expected on the basis of the first Greystone project results some tests would show a transient change during the first 3 to 6 weeks after operation, certain of the tests were repeated within 10 days after operation, but generally speaking the testing dates were -60A, -30B, +30C, +60D. The actual schedule varied somewhat from test to test.

Chapter 9

PSYCHOMETRIC STUDIES

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This chapter presents the results of psychometric and related test procedures administered to the operated and non-operated or control patients. Although a wide variety of psychometric procedures has been used previously in the evaluation of frontal lobe surgery, no clear indication of any lasting changes have been reported. (See Columbia Greystone Associates '49, for a review of earlier findings.) The number of studies in which preoperative test scores were available is relatively small however, and when they were available, comparisons were usually based upon a single administration of a test. The experimental design in the present study, by providing for 2 preoperative measures for each of the tests, has established a more adequate preoperation baseline with which postoperation test performances can be compared.

Temporary or transient changes in the immediate postoperative period following brain surgery have been observed in the Porteus Maze test (Porteus, '44; Porteus and Kepner, '44; Porteus and Peters, '47; H. E. King, '49), the Homograph (Capps) test (Malmo, '48; Beechley, et al., '49) and in the Weigl Sorting test (W. R. King, '49). These 3 test procedures were employed in the present study to investigate the nature of the temporary changes through a more extensive qualitative analysis of the tests.

The Wechsler-Bellevue Intelligence test was selected because it is the most widely used method for evaluation of the intellectual performance of adults, and also because it provides separate scores for a number of subtests, thus affording opportunity for independent evaluation of a variety of different tasks.

The Wechsler-Bellevue and Porteus Maze are standard tests in the area of general intelligence and the Homograph and Weigl in the area of sorting and shifting ability. Minor revisions were made in the administration and scoring of the Weigl and Porteus tests, and a modification of the Homograph test was developed to insure greater homogeneity in the stimulus words.

EXPERIMENTAL DESIGN

The general design called for 2 preoperative tests and 2 postoperative tests. The preoperative tests were given approximately 60 days and 30 days prior to the date set for operation. The postoperative tests were generally given 30 and 60 days postoperatively except in the case of those tests where transient immediate postoperative effects were anticipated. In such cases the retesting was done 10 days after the operation.

The same test forms were used preoperatively and postoperatively because no duplicate forms were available. In the case of the Wechsler-Bellevue, Form II was administered at an extra testing period 6 months postoperatively.

The psychometric tests were given to all of the 28 patients who were included in the second Columbia-Greystone project. (See fig. 6 and Table 5 for basic data.) Since the operative procedures varied considerably the data are to be presented in subgroups divided in accordance with the surgical procedures. These consisted of the following groupings: (1) venous ligation (VL), (2) transorbital lobotomy (TO), (3) thermocoagulation (TC), and (4) thalamotomy (TH). A preliminary examination of the results indicated that the venous ligation group contained a subgroup which differentiated itself from the rest because of a difference in the operative procedure. This group (VL-I) consisting of 4 patients was treated as a separate group in the analysis of the data. "In these four cases all the cortico-dural veins that could be seen from 2 cm. caudal, to the tips of the frontal pole as far back as 5 cm. caudal to the coronal suture (measured along the medial and superior edge of the cerebral hemisphere) were occluded. In case B1 the superior longitudinal sinus had to be ligated 2 cm. caudal to, and again 4 cm. rostral to the coronal suture, which was the only effective way of controlling bleeding from four veins flowing into the sinus between these two points. In the next seven cases (VL-II) no cortico-dural vein was occluded more than 2 cm. caudal to the coronal suture." (General Communication No. 8, January 31, 1949, Columbia-Greystone Project II.)

INTELLIGENCE TESTS

The effect of surgical interference in the brain on intellectual performance is of great concern to both the clinician as well as the research worker. The former wishes to know whether the operation reduces intellectual performance and the latter is interested in discovering relationships between the brain and mental functions. The experimental literature on frontal lobe function divides itself into 2 parts: animal studies and clinical studies utilizing testing techniques. The studies on animals in delayed reaction and problem box situations have been summarized by H. E. King ('49). Several other studies throw

additional light on the nature of the losses following frontal lobe operations. With lesions restricted to the frontal third of the cortex in rats, Loucks, ('31) and Morgan and Wood ('43) found a loss of the capacity for delayed alternation, and Stellar, et al., ('42) found a loss of the ability to estimate distance in a complex maze. Harlow, et al., ('48) working with monkeys, showed a loss in object discrimination learning, discrimination-reversal learning, complex discrimination-reversal learning, and patterned multiple string tests with bilateral extirpation of the frontal lobes. The evidence from the laboratory studies seems to indicate that impairment of the frontal lobes is associated with some "deficit" in retention of recently formed habits (which can be relearned), and in specific learning defects in certain situations.

The results of previous studies with human beings have also been summarized by H. E. King ('49). Since his review, several studies have appeared which reported decrements in intellectual functioning concomitant with brain operations. Koskoff, et al., ('48) in a study of 5 cases of lobotomy for the relief of intractable pain found that the IQ on the Wechsler-Bellevue test Form I, declined 20.4 points, the decrement occurring in both the Verbal as well as the Performance scale IQ's. Malmo ('48) utilized Form I of the Wechsler-Bellevue preoperatively and Form II postoperatively on 6 psychoneurotic patients, one of whom underwent a gyrectomy while the others underwent lobotomies. He reported a significant loss in general intelligence. In another series of 9 psychoneurotic patients, 3 of whom underwent gyrectomies and 6 lobotomies, the Stanford-Binet Vocabulary test was used and again a significant decline in intelligence was noted. Finally, Yacorzynski, et al., ('48) reported a marked intellectual decline on both the Wechsler-Bellevue, Form I and the Stanford-Binet, Form L, in one psychiatric patient who underwent a bilateral lobotomy. This study is of methodological interest in that it is the first to report 2 preoperative tests. Since previous investigations of the effects of brain operations on intellectual functioning report conflicting results, an attempt was made in this study to control as many of the variables as possible in order to provide a definitive answer to the question of the relationship between brain operation and intelligence.

WECHSLER-BELLEVUE TEST OF ADULT INTELLIGENCE. Form I of this test was used twice preoperatively, 2 months and one month before operation, to obtain a more stable and representative measure of the preoperative intellectual level as well as the range of variation of the measure itself. The immediate postoperative period was permitted to pass without retesting to avoid the complication of the possible transient effects that occur in some tests during that period.

Form I was given 4 times, twice before operation (-60A, -30B) and twice after operation (+90C and +120D). In order to evaluate the expected practice effects arising from 4 repetitions of the same test Form II was administered 6 months after operation (+180E).

PORTEUS MAZE TEST. Porteus ('44), Porteus and Kepner ('44), and Porteus and Peters ('47) have shown that in the immediate postoperative period, patients with frontal lobotomies tend to lose in mental age score but regain this loss several months after operation. H. E. King ('49) described the same phenomena in topectomy patients. A similar pattern of temporary loss followed by recovery was observed in a study of thiamine deprivation by O'Shea, et al., ('42). Since this pattern of loss and subsequent recovery has been observed in a wide variety of frontal lobe operations and in other types of interference with brain function, the likelihood that this alteration is related to any specific brain area is exceedingly doubtful. A further test of the generality or specificity of this phenomenon could be made in the present study since a wide variety of surgical procedures were utilized.

The materials used were the Porteus Mazes (Vineland Revision), which are paper and pencil mazes graded in difficulty from a mental age of 5 to 17 years (Porteus, '33; Porteus, '42). The standard instructions were modified in accordance with the findings made in an unpublished preliminary study conducted by Dr. Sarah Anderson with adult psychotic patients.

The following modifications in administration were found desirable: The Porteus instructions for years V and VI which are given in terms suitable for a childish age range, were modified to make them more adaptable to adult subjects. The injunction against pencil-lifting was introduced at year VI instead of at year V in order to eliminate confusion. In addition, the warning against pencil-lifting was repeated whenever an infraction occurred and the frequency of the pencil-lifting score obtained under these conditions provided an indication of failure to follow directions. The criterion for terminating the test was established at the level of 3 successive year-failures. The range was extended by adding the Adult II maze and allowing 4 trials for it, or a maximum credit of 2 years. Our credit allowance for the trials of Mazes XII and XIV totals the same as that given by Porteus but we have separated these 2 mazes treating each separately rather than combining the 2 mazes in trials and credits as in Porteus' instructions. Our credit allotment for Mazes XII, XIV, Adult I and Adult II was as follows: If a subject passed one of the mazes on the first trial, 2 years credit was allowed; if it required a second trial to pass, 1-1/2 years credit was given; on a third trial pass, one year credit; and on a fourth trial pass, one-half a year credit. The allotment of credit for the mazes of years V to XI inclusive is as in Porteus' standard procedure.

In the event that the subject failed both trials for Maze V, he was credited with 4 years. If the subject failed both trials for Mazes V, VI, and VII his maze performance score was 4.0, although his score might have been anywhere between 0 and 4. The above changes in scoring and procedure increased the maximum total score from the standard value of 17 to 19. This revised score was designated "The Maze Performance Score."

Since loss of planfulness has been regarded as one of the possible outcomes of psychosurgery, the degree of planfulness exhibited by the patient before entering the maze and his planfulness within the maze was rated, and recorded. The rating for preliminary planning was obtained by estimating the time interval elapsing between completion of instructions and actual movement of the pencil. It was not always possible to determine from observing the patient whether the initial delay was due to planning or to psychotic preoccupation. Consequently, this score is more in the nature of a measure of reaction time rather than pure planfulness and has been designated as the "Initial Delay Score." Since it was difficult to measure this interval with a stopwatch without making the patient aware that his delay in entering the maze was being recorded, only estimates of the initial reaction time were taken. These were rated as 0, for no delay or immediate entry into the maze (0"-4"); 1 for short hesitation (5"-12"); 2 for average delay (13"-35"); and 3 for long hesitation (36" and above). The total score for initial delay was obtained by adding all the initial delays and dividing by the number of mazes entered.

As a measure of intramaze planning, the number of pauses made by the patient after entering the maze were recorded. All pauses of one second or longer duration were recorded as indications of intramaze planning. This rating will be referred to as "Intramaze Delay." Short pencil stops which were due to mechanical reasons, such as roughness in the surface of the paper, are not recorded as intramaze delays. One problem in determining intramaze delays which arose with some patients was the tendency to make a series of complete stops of at least a second's duration with perhaps one-quarter to one-half inch pencil lines between stops. When such a series of stops and beginnings are very close together and seem to be due to the same planning period on the subject's part only one intramaze delay was recorded. It occasionally occurred that 2 separate stops were made *which were very close together but which really represented 2 planning* periods, the one just before the subject entered an opening and the other just after passing through the opening. Such stops, which really represented 2 separate plannings, were recorded as 2 pauses, although the pencil may have moved a little more than one-half an inch between the 2 stops. No intramaze delay was recorded for stops made by the subject after the subject had entered a blind alley.

These intramaze delays were tallied on the scoring sheet as they occurred during the particular trials. The final intramaze delay score is the total of all intramaze stops throughout the entire test (exclusive of Maze V), divided by the number of mazes entered.

The tests were administered 4 times, at -60A, -30B, +10C, and +90D. The 2 preoperative administrations of the tests provided a measure of intraindividual variability by which the reliability of the anticipated postoperative changes could be gauged. Furthermore, after 2 administrations, the likelihood of marked practice gains in the test is very small.

Twenty-three patients in the operated group and 6 unoperated patients were tested. Although the group of patients selected for surgery contained several severely disturbed cases, the Porteus Maze test was short enough and sufficiently interesting to evoke cooperation from all but one of the patients.

Results

WECHSLER-BELLEVUE TEST OF ADULT INTELLIGENCE ANALYSIS. The results obtained with this test are given in Table 6.

The initial level of the various subgroups varied in IQ from 71 to 99 on the Verbal scale and from 62 to 90 on the Performance scale. These ranges did not change materially with the progress of the testing periods. Those patients who received the transorbital operation were lowest both before and after operation, while the non-operated group stood highest.

In order to determine whether the effect of the operative procedures resulted in a lasting alteration of intellectual ability, the initial preoperative level at -60A was compared with the last postoperative retest on Form I at +120D. The results indicate that there is no decline below the initial preoperative level in any of the operated groups on any of the scales.

Since the comparison of preoperative and postoperative results on Form I is subject to the influence of practice effects arising from the 4 repetitions of this test, a more crucial comparison can be made between the initial administration of Form I and the administration of Form II at the +180E testing. This comparison also indicates that no lasting intellectual decline occurred in the total operated group.

The 4 cases in the severe venous ligation (VL-I) subgroup showed a decline on the Verbal scale at +90C on Form I of 4.75 IQ points below their initial preoperative level.

It may be concluded that with the exception of the group of patients who received an extensive venous ligation (VL-I), no lowering of intelligence below the initial preoperative level occurred in any of the operated patients.

An examination of the test to test results indicated a striking practice effect in all the groups. There was a consistent gain for each group beyond the initial preoperative level on all 3 scales, with the exception of the VL-I subgroup as previously noted. The relative gains for each group on the 3 scales are graphically demonstrated in figures 47 to 49.

Figure 47 shows the gains for the Full-scale IQ. In order to prevent the differences in the initial level from obscuring the graphic comparisons, each graph is drawn with its initial level at the zero point, and only gains and losses above the initial level are plotted in the graph. The 2 thermocoagulation and 2 thalamotomy patients gave marked variability throughout the testing series and hence are not included on the graph.

Table 6

MEANS OF WECHSLER-BELLEVUE FORM I AND FORM II, VERBAL, PERFORMANCE, AND FULL-SCALE IQ's BY SUBGROUPS FOR EACH OF THE 5 TESTING PERIODS

		VERBAL IQ					PERFORMANCE IQ					FULL-SCALE IQ				
Operative Technique*	N	-60A	-30B	+90C	+120D	+180E[a]	-60A	-30B	+90C	+120D	+180E[a]	-60A	-30B	+90C	+120D	+180E[a]
VL-I	4	93.25	98.50	92.75	95.25	86.75	87.00	90.25	98.25	96.75	89.00	89.50	94.50	95.25	96.25	88.00
VL-II	7	91.57	95.00	97.43	99.29	94.00	90.29	100.14	102.29	103.57	92.57	90.71	98.66	100.14	101.71	93.71
TO	7	71.71	71.71	73.57	77.00	74.17[b]	62.14	72.71	75.29	75.71	67.67[b]	65.14	70.43	73.29	75.43	69.83[b]
TC	2	76.00	81.00	86.50	92.50	86.00[b]	64.50	75.50	88.50	98.50	66.00[b]	69.00	77.50	87.00	95.00	76.06
TH	2	76.50	74.50	82.00	82.50	78.00	66.50	76.00	71.50	80.00	75.00	70.00	74.00	76.00	80.00	75.50
CONTROL	6	99.33	101.33	103.50	104.33	98.00[b]	89.16	97.66	103.66	105.83	97.40[b]	93.66	100.16	103.66	105.00	98.60[b]

*VL-I = Extensive venous ligation; VL-II = Limited venous ligation; TO = Transorbital lobotomy; TC = Thermocoagulation; TH = Thalamotomy; a = Wechsler-Bellevue Form II administered at this testing period; b = There is one less case for each of these subgroups (TO, TC, CONTROL) at this testing period.

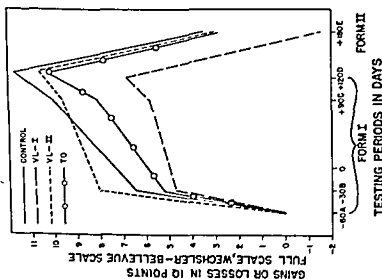


FIG. 47. The changes in IQ points made on the Wechsler-Bellevue scale of Adult Intelligence, Forms I and II (Full-scale), by the various operative groups and the control patients, at each of the 5 testing periods.

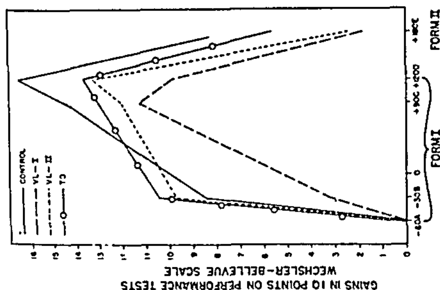


FIG. 48. The changes in IQ points made on the Wechsler-Bellevue scale of Adult Intelligence, Forms I and II (Performance scale) by the various operative groups and control patients, at each of the 5 testing periods.

The 4 groups generally showed equal gains preoperatively. After the operation, however, the operated groups tended to fall behind the control group in their gains. The greatest discrepancy from the control group's performance was shown by the VL-I group. All of the groups show a steep decline in score at the last testing period when Wechsler-Bellevue, Form II was used. The continued practice effects on Form I had inflated the scores of all the groups spuriously. Since much of this practice effect could not be transferred to the new form of the test, the score on the latter showed an apparent decline.

Figure 48 gives the data for the Performance scale IQ. In this scale the operated groups fell behind the control group in their postoperative gains. The VL-I group again showed the maximum loss in comparison to the control group.

The data for the Verbal scale IQ are presented in figure 49. The previous 2 graphs showed a consistent advantage for the control group

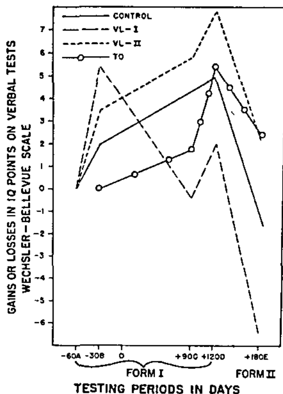


FIG 49. The changes in IQ points made on the Wechsler-Bellevue scale of Adult Intelligence, Forms I and II, (Verbal scale) by the various operative groups and control patients, at each of the 5 testing periods.

in its postoperative gains, but no such consistent advantage appears in the Verbal scale. The less complete venous ligation (VL-II) and transorbital subgroups show no consistent deviation from the control cases in postoperative practice gains on the Verbal scale. The VL-I

subgroup gained more than the control group preoperatively but they declined below their initial preoperative level on both Forms I and II after operation. The graphic analysis indicates a consistent discrepancy between the operated and unoperated groups in practice gains on the Performance scale. To determine the magnitude of this difference, the preoperative and postoperative gains on the Performance scale were analyzed statistically. This analysis is given in Table 7.

Table 7

PREOPERATIVE AND POSTOPERATIVE GAINS ON FORM I OF THE PERFORMANCE SCALE IQ OF THE WECHSLER-BELLEVUE TEST FOR THE OPERATED AND CONTROL PATIENTS

		Gains		Difference
Groups	N	Preoperative -30B less -60A	Postoperative +120D less -30B	
Operated	18	8.67	3.95	4.72
Control	6	8.50	8.15	0.35
Difference		0.17	-4.20	4.37
Critical Ratio				2.68

Although both the operated as well as the control group benefited equally in their preoperative practice, each gaining about 8.5 IQ points, their postoperative gains differ significantly. While the control group continued to gain 8.15 points in the 2 months following the date of operation, the operated patients gained only 3.95 points in that period of time. The difference between these gains is significant on the .05 level.

Practice effects may be divided into 2 parts: (1) those which are specific to the particular items in Form I and which benefit from memory of previous administration of that form, and (2) those which are independent of the specific content of Form I but which reflect general familiarity with the material which characterizes the Wechsler-Bellevue test. These general practice effects gained in Form I, are in all probability transferable to Form II.

In Table 8 the initial administration of Form I, free of the subsequent practice, is compared with the final performance on Form II which should also be relatively free from the influence of specific familiarity with Form I.

When the practice effects on Form I are deflated in this manner, the control patients still show a marked advantage in gain over the operated group on the Performance scale and to a lesser degree on the Full-scale. There is again no consistent deviation between the operated and control groups on the Verbal scale.

Table 8

WECHSLER-BELLEVUE FORM I RESULTS OBTAINED AT FIRST ADMINISTRATION (-60A) AND FORM II OBTAINED 8 MONTHS LATER (+180E) ANALYZED BY SUBGROUPS

		VERBAL IQ			PERFORMANCE IQ			FULL-SCALE IQ		
Operative Technique	N	-60A Form I	+180E Form II	Difference	-60A Form I	+180E Form II	Difference	-60A Form I	+180E Form II	Difference
VL-I	4	93.25	86.75	-6.50	87.00	89.00	+2.00	89.50	88.00	-1.50
VL-II	7	91.57	94.00	+2.43	90.29	92.57	+2.28	90.71	93.71	+3.00
TO	6	71.66	74.17	+2.51	61.66	67.67	+6.01	64.83	69.83	+5.00
TC	1	72.00	86.00	+14.00	62.00	66.00	+4.00	65.00	76.00	+11.00
TH	2	76.50	78.00	+1.50	66.50	75.00	+8.50	70.00	75.50	+5.50
CONTROL	5	96.60	98.80	+2.20	86.80	97.40	+10.60	90.80	98.60	+7.80

This discrepancy between the control and operated groups on the Performance scale of Form II was statistically analyzed. The control group gained 10.6 IQ points from initial to final tests, while the venous ligation and thalamotomy groups gained only 3.53 points. This difference was statistically significant on the .05 level (C.R.=2.35). It is clear that the operated patients in this group transferred a greater proportion of their practice gains from Form I to Form II than did the control group. The specific practice effects in Form I as well as the general practice effects from Form I to Form II are less apparent in the operated group than in the control group.

The VL-I group not only fell behind in practice gains on the Performance scale but also actually declined below their initial preoperative level on the Verbal scale on Forms I and II. The data was treated statistically to determine the reliability of this decline. Table 9 shows the preoperative and postoperative gains and losses in both the VL-I and control cases on Form I.

Table 9

PREOPERATIVE AND POSTOPERATIVE GAINS ON THE VERBAL SCALE OF FORM I OF THE WECHSLER-BELLEVUE SCALE FOR THE VL-I AND CONTROL GROUPS

		Gains		Difference
Groups	N	Preoperative -30B less -60A	Postoperative +120D less -30B	
VL-I	4	+5.25	-3.25	-8.50
Control	6	+2.00	+3.00	+1.00
Difference		3.25	-6.25	-9.50
Critical Ratio				1.12

The VL-I subgroup gained 5.25 points during the preoperative period but lost 3.25 points in the postoperative period, showing a net loss of 8.50 IQ points. The control group gained 2.0 points in the preoperative period and 3.0 points in the postoperative period, showing a net gain of 1.0 IQ points. The difference between the 2 groups is, however, not statistically reliable.

A comparison of the net gain between the initial Verbal IQ (Form I) and the final Verbal IQ (Form II) for the VL-I and control cases was made. The non-operated group showed a gain of 2.20 points while the VL-I patients showed a loss of -6.50 IQ points. This difference was statistically significant on the .05 level (C.R.=2.59), indicating that a reliable decrement had taken place in the VL-I subgroup.

It is interesting to note here that when the specific practice effects present in the repeated retests with Form I are removed it is possible

to establish a reliable decline on the Verbal scale below initial preoperative level in the 4 cases of the VL-I subgroup.

In summarizing the findings on the Full-scale, Verbal and Performance scales for the operated and control groups, it must be emphasized that there was no decrease in intellectual functioning below the initial preoperative level, except as noted in the VL-I subgroup. There was a significant difference in the ability to profit from practice on the Performance scale between the operated and control groups.

We may now turn our attention to an analysis of the subtests. The preoperative and postoperative reliabilities of the tests are shown in Table 10.

Table 10

CORRELATIONS FOR WECHSLER-BELLEVUE IQ'S AND SUBTEST WEIGHTED SCORES FOR THE PATIENT GROUP

	FORM I (N = 28)		FORM I AND II (N = 24)
Subtests	Between -60A and -30B	Between -90C and +120D	Between -60A and +180E
Verbal IQ	.914	.954	.908
Performance IQ	.928	.998	.803
Full-Scale IQ	.931	.952	.804
Information	.774	.897	.827
Comprehension	.844	.707	.511
Digit Span	.668	.528	.518
Arithmetic	.871	.740	.771
Similarities	.847	.916	.719
Vocabulary	.813	.942	.904
Picture Arrangement	.645	.539	.296
Picture Completion	.823	.835	.744
Block Design	.818	.734	.614
Object Assembly	.823	.771	.375
Digit Symbol	.728	.654	.761

The reliability coefficients of the scales as well as of the subtests are consistently high both preoperatively as well as postoperatively. The correlation between the initial preoperative application of Form I and the application of Form II postoperatively was also consistently high except for 2 subtests, Picture Arrangement and Object Assembly. Excluding these 2 tests, it may be concluded that the operation did not

disrupt the rank order of ability in the group. The decrease in reliability of the 2 subtests mentioned earlier may be a function of the disparity in the corresponding subtests on the 2 scales.

A summary of the mean weighted subtest scores on the Verbal scale for the operated and control groups is presented in Table 11.

There is no consistent trend evident on the verbal subtest scores which might differentiate the operated and control groups. The subtest scores reflect the total verbal score where there was a consistent gain from the initial preoperative level with no marked disparity between the operated and non-operated groups.

A summary of the mean weighted subtest scores on the Performance scale for the operated and control groups is presented in Table 12. With the small number of cases available and the different intelligence levels within the operated subgroups, it is not possible to establish any statistically reliable difference for individual subtests. Picture Arrangement and Object Assembly seem to show the most consistent differences in mean gain after operation between the control group and both the VL and TO subgroups. Block design shows a consistent decrease in gain after operation for the VL subgroup as compared with the control group, while the TO subgroup shows a comparative increase.

It is interesting to note that where the reliability is lowest between Forms I and II (Picture Arrangement and Object Assembly), there is also a greater divergence between the operated and control groups. The VL-I subgroup, as previously noted, showed a decrease postoperatively on the Verbal scale. A comparison of the mean weighted subtest scores on the Verbal scale between these patients and the control group is presented in Table 13. There is a consistent decrease in all verbal subtests except Information and Comprehension after operation for the VL-I subgroups, but the differences are not statistically reliable.

WECHSLER-BELLEVUE DISCUSSION. The results of this study indicate that surgical intervention in the frontal lobes does not cause any decline in the preoperatively determined intellectual level of the patient. This finding is in agreement with the reports of most previous studies. The basis for such disagreements that did occur must be sought in the nature of tests used and in the intervals of time between testing and operation as well as between the tests themselves. Generally speaking, retests performed within the first few weeks after operation are likely not to be representative of the patient's level which he will achieve 3 to 6 months after operation. The time elapsing between the first test and the retest may also be a factor producing differences since memory may be involved. Furthermore, the content of the tests, whether verbal or performance, may determine to some extent the effect of the operation on test scores.

A review of the literature (H.E. King, '49) on the effects of organic brain damage indicates that the earlier studies, which utilized the

Table 11

WEIGHTED SCORES ON VERBAL SCALE *SUBTESTS OF* WECHSLER-BELLEVUE, FORM I AND FORM II, BY SUBGROUPS FOR EACH TESTING PERIOD, FOR THE VENOUS LIGATION, TRANSORBITAL, AND CONTROL GROUPS

	-60A			-30B			+90C			+120D			+180E		
Subtests	VL	TO	C	VL	TO	C	VL	TO	C	VL	TO	C	VL	TO	C
Information	9.00	6.00	9.50	10.10	6.86	10.50	9.90	7.71	10.83	10.30	7.57	10.83	9.10	6.00	8.20
Comprehension	7.30	3.57	7.50	7.10	3.57	7.16	8.00	3.14	7.66	8.20	3.86	8.50	7.30	4.66	9.80
Digit Span	6.40	5.14	8.16	7.10	4.00	8.33	6.90	5.29	8.66	6.20	4.57	7.16	6.70	4.33	6.60
Arithmetic	6.70	1.00	6.83	7.60	2.43	8.00	7.50	1.29	8.50	8.30	3.71	7.83	6.40	3.33	7.20
Similarities	8.50	4.00	9.33	9.60	3.86	10.50	9.50	5.00	10.83	10.20	5.57	11.33	8.30	5.33	9.20
Vocabulary	9.20	7.29	11.16	9.10	6.57	10.33	9.40	7.86	11.16	10.20	7.43	11.00	10.00	7.33	11.20

Table 12

WEIGHTED SCORES ON PERFORMANCE SCALE SUBTESTS OF WECHSLER-BELLEVUE, FORM I AND FORM II, BY SUBGROUPS FOR EACH TESTING PERIOD, FOR THE VENOUS LIGATION, TRANSORBITAL, AND CONTROL GROUPS

	-60A			-30B			+90C			+120D			+180E		
Subtests	VL	TO	C	VL	TO	C	VL	TO	C	VL	TO	C	VL	TO	C
Picture Arrangement	6.60	3.00	6.83	7.40	5.00	7.50	7.40	4.29	8.83	8.20	4.43	8.67	6.00	2.83	7.80
Picture Completion	6.60	2.57	6.33	8.60	3.71	9.33	9.30	4.14	9.84	9.30	5.17	9.33	8.00	5.50	7.80
Block Design	6.70	2.50	7.17	8.20	4.71	7.83	8.60	5.17	8.67	8.40	6.14	9.33	7.40	5.33	8.80
Object Assembly	8.30	6.84	7.34	9.90	8.00	9.84	12.00	9.15	11.17	10.80	7.86	10.83	8.90	7.34	10.30
Digit Symbol	6.00	2.00	4.83	6.80	3.57	6.50	6.30	3.86	6.33	6.80	4.00	7.66	6.50	2.50	6.60

Table 13

WEIGHTED SCORES ON VERBAL SCALE SUBTESTS OF WECHSLER-BELLEVUE FORM I AND FORM II FOR THE VL-I AND CONTROL GROUPS FOR EACH TESTING PERIOD

Subtests	VL-I -60A	C	VL-I -30B	C	VL-I +90C	C	VL-I +120D	C	VL-I +180E	C
Information	9.25	9.50	10.50	10.50	10.00	10.83	10.50	10.83	8.25	8.20
Comprehension	7.75	7.50	7.50	7.16	8.25	7.66	8.75	8.50	6.25	9.80
Digit Span	5.25	8.16	6.25	8.33	4.75	8.66	4.75	7.16	5.50	6.60
Arithmetic	6.50	6.83	7.25	8.00	6.00	8.50	7.25	7.83	5.75	7.20
Similarities	9.00	9.33	11.00	10.50	8.75	10.83	9.25	11.33	7.00	9.20
Vocabulary	9.25	11.16	10.25	10.33	9.25	11.16	10.25	11.00	9.50	11.20

Stanford-Binet Intelligence scale, which consists primarily of verbal material reported no increase in general intelligence. In the later studies on frontal lobe cases which utilized the Wechsler-Bellevue test, Koskoff ('48) in intractable pain cases, Malmo ('48) using Form I preoperatively and Form II postoperatively, and Yacorzynski, et al. ('48) all found postoperative deficits. H.E. King ('49) who reported no general impairment of function, nevertheless found possible impairment in several of the performance subtests. One of the reasons for this difference in results on the Stanford-Binet and Wechsler-Bellevue Intelligence tests may arise from the fact that the Wechsler-Bellevue scale includes a wider range of both verbal and performance subtests.

The present study found evidence of an interference with the ability to benefit from continued practice on the Performance scale of the Wechsler-Bellevue. H.E. King ('49) also noted a tendency for the topectomized patients to profit less from practice as compared with a control group. Since previous studies failed to give more than one preoperative test, the role of practice on test results has been difficult to evaluate. In the present study, both the preoperative and the postoperative practice effect could be evaluated and compared. The greatest gain from practice appeared between the initial and the second preoperative tests. These gains were significant on the Performance and Full-scale scores but not on the Verbal scale. After this initial gain, the operated group continued to make further gains but not at the same rate as the non-operated group. There was a significant differential in rate of improvement after operation between the operated and non-operated groups, consistent for all 3 surgical operative procedures, in the performance but not in the verbal scores.

Another question that may be asked is: How well does an operated patient carry over what he has practiced or experienced in one situation to another similar situation? A comparison between the initial preoperative level on the Performance scale of Form I and Form II scores indicates a lowered ability to transfer the practice effects from Form I to Form II for the operated patients as compared with the non-operated patients. There seems to be a relationship here between the severity of the operation and the inability to carry over practice effects from one situation to another. The comparative decrement is greatest in the VL-I subgroup and least in the TO subgroup. The patients in the VL-I subgroup, not only showed a lessened capacity to gain from practice on the performance scores, but they also showed a consistent deficit on the Verbal scale which brought them below their initial preoperative level. H. E. King ('49) found a greater degree of impairment lasting over a longer period on the Wechsler-Bellevue test in a group of topectomized patients in whom area 8 was excised. W. R. King ('49) similarly found in the same group of topectomy patients a tendency for the number of "Marked Decrease scores" on an Object Sorting test to diminish in frequency as one moves rostrally over the frontal cortex from area 6 to area 11. There appears to be a relationship between the posterior extent of frontal lobe involvement and decreased efficiency in test performance.

SUMMARY OF FINDINGS WITH WECHSLER-BELLEVUE TEST.

1. The operative procedures did not reduce the general intellectual functioning of the patients below their initial preoperative level.

2. The rate of improvement attributable to practice, which characterized all the patients preoperatively, showed a deficit in the surgical cases after operation on the Performance scale.

3. The 4 patients who underwent the more severe (posterior) venous ligations exhibited not only a failure to benefit from practice on the Performance scale, but also an actual decrement below their original preoperative level on the Verbal scale.

PORTEUS MAZE TEST ANALYSIS. The average scores for each of the surgical groups for the 4 testing periods are shown in Table 14.

Table 14

MEAN SCORES ON THE PORTEUS MAZE TEST EXPRESSED AS YEARS OF MENTAL AGE FOR THE DIFFERENT TEST PERIODS AND VARIETIES OF OPERATIONS

Operative Technique	N	Testing Period -60A	-30B	+10C	+90D	Immediate Postoperative Loss (-30A) less (+10C)
VL-I	4	8.4	9.4	5.5	11.1	3.9
VL-II	7	10.4	12.4	12.2	14.5	0.2
TO	8	9.5	11.5	10.7	11.4	0.8
TC	2	4.25	7.25	5.75	9.25	1.5
TH	2	9.75	9.5	4.75	7.5	4.2
All	23	8.7	10.8	9.3	11.8	1.5
Control	6	12.8	13.3	13.3	14.3	-.05

There are 4 questions to be answered by these data. (1) Did the preoperative tests improve with practice? (2) Was there a drop in score in the immediate postoperative period? (3) Was this loss regained? (4) What explanation can be offered for the observed changes?

The operated group increased in maze performance score from the first to the second preoperative testing by 2.1 years of mental age. The corresponding increase in the control cases was only 0.4 years of mental age. An examination of the surgical subgroups indicates that all except the 2 thalamotomy cases showed the influence of the practice

effect. It is noteworthy that the non-operated group performed on a much higher level (12.8 years) initially than did the operated group (8.7 years), and consequently the discrepancy in practice effect may in part be due to the initial inequality of the 2 groups. The data are graphically presented in figure 50. An immediate postoperative loss

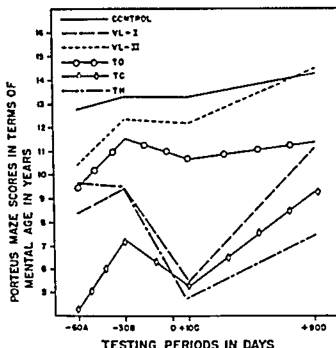


FIG. 50. The changes in Mental Age scores made on the Porteus Maze test by the various operative groups and control patients at each of the 4 testing periods.

occurred in each of the groups and ranged from 0.8 years of mental age in the transorbital lobotomy group to 4.7 years in the thalamotomy group, with an average of 1.5 years for the whole operated group. The non-operated group showed no loss for this testing period.

The immediate postoperative drop was, however, not a drop in basic ability, since these scores were still above the original preoperative level. Only the 2 patients in the TH group and the 4 patients in the VL-I group showed a drop below the original level. The rest gave up some of the advantage that had accrued to them from the preoperative practice.

At the final testing period, all the patients excepting the 2 thalamotomy cases recovered their immediate postoperative losses and continued to make gains beyond that point. (The same pattern of immediate loss and subsequent gain was observed in 2 additional patients who had only one preoperative test and are not included in Table 14.)

The next question to be considered is the effect of the operations on gains attributable to practice. The gains in the preoperative period

(-30B) less (-90A) and the gains in the postoperative period (+90D) less (-30B) are shown in Table 15.

Table 15

COMPARISON OF GAINS IN MONTHS OF MENTAL AGE ON THE PORTEUS MAZE TEST BEFORE AND AFTER OPERATION

		Gains		Net Gain
Operative Technique	N	Preoperative (-30B) less (-60A)	Postoperative (+90D) less (-30B)	(+90D) less twice (-30B) plus (-60A)
VL-I	4	1.0	1.7	0.7
VL-II	7	2.0	2.1	0.1
TO	8	2.0	-0.1	-2.1
TC	2	3.0	2.0	-1.0
TH	2	0.25	-2.0	-1.75
All	23	2.1	1.0	-1.1
Control	6	0.45	1.05	0.6

The control group showed a preoperative gain of 0.45 points while the entire operated group gained 2.10 points, indicating that before surgery the operated group exhibited considerable capacity to benefit from practice, and in fact, exceeded the control group in this regard. Postoperatively, the control group increased its gains while the entire operated group gained comparatively less. Comparing the preoperative gains with the postoperative gains, the control group showed a gain of 0.60 points while the operated group showed a loss of 1.10 points. Apparently the operated group reduced the rate at which practice improved its performance. Whether this discrepancy in rate of improvement is attributable to the operation or whether it is a function of the difference in the initial level of the 2 groups cannot be decided on the basis of the present data.

The qualitative ratings of performance on the Porteus Maze test consisted of: (1) initial delay, (2) intramaze delay, and (3) pencil-lifting.

The average rating for initial delay per maze is given in Table 16. The results indicate that the control patients as well as the operated tended to increase their initial delay ratings preoperatively from the first to the second testing. But in the postoperative period the non-operated cases declined in this rating and finally returned to their initial preoperative level, while the operated group continued to show longer delays postoperatively. Whether the prolonged delays are to

Table 16

MEAN INITIAL DELAY PER MAZE IN THE OPERATED AND CONTROL GROUPS

Operative Technique	N	-90A	-30B	+10C	+90D
VL-I	4	.74	.43	1.21	1.37
VL-II	7	1.09	1.31	1.13	0.86
TO	8	0.35	1.07	0.17	0.00
TC	2	0.10	1.36	0.00	1.19
TH	2	0.62	1.05	1.13	1.19
All	23	0.87	0.99	1.07	1.05
Control	6	1.09	1.23	0.90	1.11

be taken as an indication of greater planfulness or of postoperative slowing down cannot be determined from the data at hand.

The average rating for intramaze delays per maze is shown in Table 17. Both the operated and the unoperated groups followed the same pattern of change making only slight increases in this delay rating in the preoperative tests. In the immediate postoperative testing the control group continued to increase its delay rating while the operated group decreased somewhat, but in the final postoperative testing the operated group had increased its delay rating as much above its initial level as did the control group. Most of the final increase in the operated group seems to have occurred in the VL-II group. Here again the VL-II group which had shown the largest amount of gain in mental age also shows the greatest gain in intramaze delay. The VL-I group showed a lesser delay rating than the VL-II group throughout the testing periods.

The last qualitative measure is the response to the injunction against pencil-lifting. The number of times this infraction of the rule occurred per maze (errors per maze) is shown in Table 18.

Both the operated and the unoperated groups declined equally in the number of errors from the first to the second preoperative testings. In the immediate postoperative testing the control group continued to decline while the operated group increased in the number of errors and then returned to the level of its second preoperative test.

Table 17

MEAN INTRATEST MAZE DELAY RATING IN THE OPERATED AND CONTROL GROUPS

Operative Technique	N	-90A	-30B	+10C	+90D
VL-I	4	1.4	1.4	1.2	2.2
VL-II	7	1.9	2.0	2.4	6.0
TO	8	1.8	1.8	2.1	2.5
TC	2	1.3	2.1	0.9	3.5
TH	2	0.9	1.5	0.8	1.1
All	23	1.7	1.8	2.0	2.9
Control	6	1.7	2.5	2.7	3.0

Table 18

MEAN PENCIL-LIFTING ERRORS PER MAZE IN THE OPERATED AND CONTROL PATIENTS

Operative Technique	N	-90A	-30B	+10C	+90D
VL-I	4	.33	.32	1.08	.56
VL-II	7	.36	.11	.12	.07
TO	8	.48	.33	.26	.27
TC	2	.90	.39	.25	.41
TH	2	.12	.32	.50	.05
All	23	.38	.26	.32	.26
Control	6	.32	.28	[illegible]	[illegible]

Apparently the control group benefited more from practice in this respect than the operated group. The VL-II group made consistently fewer errors than the VL-I group.

PORTEUS MAZE DISCUSSION. The pattern of immediate loss followed by subsequent recovery which was found in this study confirms the previous findings of Porteus ('44) and of H.E. King ('49) and presents further evidence that the observed pattern is not related to the removal of any specific brain area or to the type of surgical operation. The fact that it is also found in experiments involving thiamine deprivation would suggest that the effect is probably related to physiologic changes of the entire brain.

Previous investigators reported a loss in the immediate postoperative period indicating a decline below the initial preoperative level. In the present study only the 2 thalamotomy cases and the 4 VL-I cases showed such drops. This difference may be due to the preoperative practice afforded in this study. The learning or practice in the 2 preoperative testing periods may have prevented postoperative declines below the initial level. The control group improved in the last 2 testings in the tendency to follow the rules against pencil-lifting set by the examiner while the operated group failed to show such improvement postoperatively. The other 2 qualitative measures did not show such definite results. The VL-I group which showed a more marked decline in performance postoperatively than the VL-II group, also made considerably more errors and fewer intramaze delays.

PORTEUS MAZE SUMMARY. 1. A drop in score in the immediate postoperative period was observed together with a subsequent recovery of function after 3 months. The 2 thalamotomy cases, however, failed to return to their preoperative level within the period of observation.

2. The immediate effect of the operation varied with the type of surgical procedure but generally speaking it did not reduce the patient's initially demonstrated capacity, although it curtailed somewhat the gains arising from practice and familiarity with the test in the immediate postoperative period. In the 2 thalamotomy cases, and in the VL-I group an actual drop in function below the initial level occurred.

3. The gains from practice in the postoperative period are smaller in the operated group than in the unoperated group.

SORTING AND SHIFT TESTS

W. R. King ('49) analyzed the "abstract behavior attitude" postulated by Goldstein, into 3 underlying components: (1) shift, (2) isolation, and (3) grouping. The isolation factor failed to demonstrate any changes referable to brain operation in the first Columbia-Greystone study. In 6 of 9 cases the grouping factor showed some tendency to be

affected when area 9 was removed, but failed to show any change after operation when both areas 9 and 46 were removed. The shift factor gave the clearest indication of a change after operation with a loss in ability to shift in 5 out of 8 patients on the Weigl Sorting test when area 46 was ablated.

In attempting to relate these 3 factors to the present investigation and to previous studies, the concept of "mental set" may be introduced as a link between much of the previous work. The grouping factor may be regarded as dependent on the capacity to assume and maintain a mental set as well as on the capacity to execute behavior in accordance with the assumed mental set. The shift factor may be regarded as the capacity to inhibit or eliminate one mental set in order to assume another.

Several other investigators have applied "set" tests to mental patients undergoing brain operation and have found that specific grouping sets as well as shift of set are more difficult for patients with frontal lobe involvement. Halstead ('47) pointed out that frontal lobectomy cases maintained a rigidity of set (inability to shift) despite a mounting number of errors which in a normal individual would bring about an alteration in set. Malmo ('48) on a group of gyrectomy patients similarly concluded that the ability to adopt a set towards a goal is dependent on the intactness of the frontal lobe. M. F. Robinson in her study of lobotomy cases ('49) reported a reduction in the ability to maintain a set, and in an earlier study ('46) she maintained that shift ability was interfered with in operated cases. In the first Columbia-Greystone project, the Weigl Sorting test (W. R. King, '49) and the Capps Homograph test (Beechley, et al., '49) reported some indications of a similar loss in the immediate postoperative period for the group of topectomy patients. It is interesting to note that these studies, using different test procedure, seem to reach some agreement that surgical intervention in the frontal lobes, whether it be by means of lobectomy, gyrectomy, lobotomy, or topectomy, may interfere in some way with the ability to maintain and shift set. In the present study a modified form of both the Weigl and Homograph tests was used to investigate further the shift factor with respect to set.

The Tests

WEIGL SORTING TEST PROCEDURE. The description of this test and the directions for its use and scoring were given by W. R. King ('49). The present application of the test differed only in 2 respects from the method used by King. Instead of the numerical scoring the present study classified the performance into the same categories that he used, but did not utilize total scores. Furthermore, if the patient failed to shift, no *demonstration of the correct sorting was provided,* since it was felt that the demonstration might affect the postoperative performance.

REVISED HOMOGRAPH TEST PROCEDURE. The purpose of this test was to investigate the patient's capacity to shift from one meaning of a word to another meaning. For this purpose words were selected with several distinct meanings and the patient asked to give all the meanings he could think of. A general difficulty in obtaining comparable results with the original test (Capps, '39) stemmed from the fact that the stimulus words differed in the number of different definitions which they might elicit. In order to overcome this difficulty, the original Homograph test was revised so as to include words with only 4 common and distinct definition categories for each word. By definition category is meant a class of more or less equivalent definitions. For example, to the stimulus word "rule" one definition category included all *the meanings dealing with the concept of "governing"* (be king, command, reign over); while a second definition category subsumed all the definitions dealing with the concept of regulation, law or principle (a guide, a law, regulation, etc.); a third definition category included all definitions involving the concept of using a ruler to draw lines; and the fourth definition category included all the definitions involving the concept of graduated strips of wood or metal used for measuring (ruler). The 12 stimulus words comprising the revised Homograph test are given in Table 22.

The stimulus words were presented orally and the subject was asked to give as many different meanings as he could for each word. The standard instructions are:

> I am going to say some words and I want you to give me as many meanings as you can for each word. I'll keep asking you for additional meanings until you can't think of anymore.

As an example the subject is asked to tell what the word "bill" could mean and is encouraged to give as many meanings as possible. Two minutes are allowed for each word in the list.

A master sheet was set up with the 4 definition categories for each word. One credit was given for each definition category, with no extra credit given for several variations of one meaning, combination words, or names. There were very few definitions given which did not fall into the established categories and these were not included in the scoring. Rigorous dictionary definitions were not required while the rules established for crediting definitions on the Terman-Merrill ('37) Stanford Revision were followed.

The shift score was the total number of different meanings given for each word exclusive of the first meaning. It was computed by subtracting the total number of words with at least one meaning from the total number of different meanings (for example, if 22 different correct meanings were given with at least one meaning for each of the 12 words the shift score was 10).

WEIGL SORTING TEST ANALYSIS. This test provided 2 scores, (1) a performance score indicating the accuracy of the sorting performance, and (2) a verbalization score indicating the adequacy of the explanation given by the patient of the basis for his sorting.

The performance score was classified either as a success or a failure, depending on whether the patient could sort for both categories and in that way exhibit his ability or lack of ability for shifting from one sorting basis to the other. The number of patients able to shift at each of the 4 testing periods is shown in Table 19. Initially, the

Table 19

NUMBER OF "SHIFTERS" ON THE WEIGL PERFORMANCE SCORES BY SUBGROUPS FOR THE 4 TESTING PERIODS

Operative Technique	N	-60A	-30B	+10C	+90D
VL	11	6	10	6	10
TO	7	2	6	2	3
TC	2	1	1	0	0
TH	2	1	1	0	0
All	22	10	18	8	13
Control	6	3	5	5	5

operated and non-operated group consisted of an equal number of "shifters" and "non-shifters." In the second preoperative testing period (-30B) the control group improved to the point where only one patient of the 6 was unable to shift and the operated group also improved to the same extent, only 4 patients of 22 being unable to shift. In the 2 postoperative testing periods no further improvement occurred in the control group but a definite decline in the number of shifters from 18 out of 22 to 9 out of 22 occurred in the operated group. In the last retest, the operated group regained some of its losses but did not quite return to its preoperative level, only 13 out of 22 being able to shift. This increase in the number of those operated patients able to shift comes from all surgical groups except the transorbital. If one considers all operated cases as a group and compares them to the control group then the number showing the loss is statistically

significant. However, the meaning of this significance is related to the psychosis as well as the operation. Other evidence indicates that "shifting" or "non-shifting" is related to the schizophrenic psychotic process, in that many schizophrenic patients show "shift" variations in performance on this test. It is most probable, since so few of the operated patients showed any improvement from their psychosis, that the losses found were due to oscillations in the psychosis rather than to the operation.

A summary of the Weigl verbalization scores is presented in Table 20. These scores followed the pattern of change already noted in the

Table 20

WEIGL VERBALIZATION MEAN SCORES BY SUBGROUPS FOR EACH OF THE 4 TESTING PERIODS

Operative Technique	N	-60A	-30B	+10C	+90D
VL-I	4	3.50	4.25	2.50	4.25
VL-II	7	4.71	5.86	4.86	5.57
TO	7	2.43	4.43	3.57	3.71
TC	2	3.00	3.00	1.50	2.00
TH	2	2.00	1.00	1.00	1.50
All	22	3.50	4.75	3.60	4.30
Control	6	4.16	5.17	5.50	5.50

performance scores. There was a gain between -60A and -30B, an immediate postoperative loss between -30B and +10C, and a recovery between +10C and +90D for the operated patients group. The control group showed an improvement at the second testing period and at +10C, with no change at +90D. The thalamotomy group showed a loss at -30B, no change at +10C, with a gain at +90D.

The improvement in verbal scores between the first and second testing periods observed in both the operated and control groups is understandable in the same terms as the performance scores, namely oscillations in the schizophrenic psychotic process.

REVISED HOMOGRAPH TEST ANALYSIS. The shift scores which indicate the total number of shifts in definitions of the same word were computed for each patient and the average number of shifts per patient in each of the groups is shown in Table 21. A comparison of the initial scores at -60A with those obtained at -30B yields a decrease in test scores; that is, instead of benefiting from practice most of the operated groups show a loss. A careful analysis of the subgroup data with special reference to interexaminer variability indicated that these results were attributable to the different procedures utilized by the several examiners who administered the initial test. Since all the remaining tests were given by the same examiner, this source of variation is not a factor in the subsequent comparisons.

Taking the testing results at -30B as a starting point, it is apparent that all of the operated patients showed a decrease in "shifting ability" 10 days after operation while the non-operated group gained an average of 1.5 points. Ninety days after surgery the operated groups as a whole regained their losses. The proportional gains were 6 per cent for the operated and 12 per cent for the controls. The final postoperative test score at +90D exceeded the initial performance for the operated group as a whole in contrast to the Weigl test where the final performance did not return to its preoperative level. Two of the operated groups, VL-I and TH failed to regain their preoperative level in 90 days while the VL-II and TC groups exceeded their preoperative level. The TO group recouped its losses but made no further gains.

The performance on the Capps test exhibits the pattern of an immediate but transient decline followed by subsequent recovery that characterized the Porteus and the Weigl tests.

REVISED HOMOGRAPH TEST ITEM ANALYSIS. Although the stimulus words each had 4 possible categories of dictionary definitions they differed from each other in the number of definitions elicited. Furthermore, for each word, the definition categories varied considerably in frequency of occurrence for the patients under study. The stimulus words were grouped into 2 classes, Class A with more frequent definitions, and Class B with less frequent definitions. The definition categories themselves were also grouped according to frequency into 2 groups, Group I, the more popular definition categories, and Group II, the less popular definition categories. The classification of the stimulus words and the frequency of each definition category are shown in Table 22. Because of the variation in type of stimulus word and type of definition, a further analysis was made of the average number of definition categories per word at each of the testing periods.

Several questions might be raised regarding the effect of the lack of homogeneity of test items on the outcome. (a) Did the losses occur chiefly in the more difficult definition categories? (b) Was there any tendency toward compensation by giving new definitions to replace the lost ones? (c) Were the definition categories that were lost at +10C regained at +90D? These questions will be considered in turn.

Table 21

MEANS OF HOMOGRAPH SHIFT SCORES BY SUBGROUPS FOR EACH TEST PERIOD

Operative Technique	N	-60A	-30B	+10C	+90D	Immediate Post-operative Loss (-30B) less (+10C)		Final Post-operative Gain (+90D) less (-30B)	
VL-I	4	9.40	9.00	4.50	6.00	-4.50	(-50.0%)	-3.00	(-33.0%)
VL-II	7	10.86	8.43	8.00	10.57	-0.43	(-05.1%)	2.14	(+25.4%)
TO	7	5.86	4.71	3.29	4.71	-1.42	(-30.1%)	0.00	(00.0%)
TC	2	6.50	5.50	1.00	8.00	-4.50	(-81.8%)	2.50	(+45.5%)
TH	2	2.00	3.50	3.50	1.00	0.00	(00.0%)	-2.50	(-71.4%)
All	22	8.40	6.95	3.72	4.29	-2.00	(-28.9%)	0.40	(+ 5.8%)
Control	6	9.67	10.00	11.50	11.50	1.50	(+15.0%)	1.50	(+15.0%)

Table 22

THORNDIKE WORD-COUNT RATING FOR STIMULUS WORD IN REVISED HOMOGRAPH TEST AND FREQUENCY OF EACH DEFINITION CATEGORY IN 28 PATIENTS STUDIED

Stimulus Word	Word No.	Frequency Rank in This Group	Thorndike ('44) Rating in Thousand Frequency	Most Frequent Definition Category I	Least Frequent Definition Category II	Total Definitions Given by this Group
	Class A					
Rule	6	1	1	140	66	206
Skirt	4	2	2	135	22	157
Diamond	10	3	2	162	17	179
File	1	4	3	179	35	214
Bond	3	5	2	149	11	160
Club	7	6	1	185	31	216
	Class B					
Gum	2	7	6	150	27	177
Lumber	5	8	3	104	19	123
Lump	8	9	4	110	14	124
Duck	9	10	3	172	41	213
Mean	11	11	1	137	7	144
Cell	12	12	2	156	14	170

With respect to the first question (are losses related to the difficulty in finding definitions) a loss might reflect a general lowering of intellectual ability rather than a lowering of flexibility or an inability "to shift set."

The average number of definition categories per stimulus word are shown in figure 51 for the surgical cases at testing periods -30B, +10C, and +90D. In the graph the stimulus words are entered in the order of

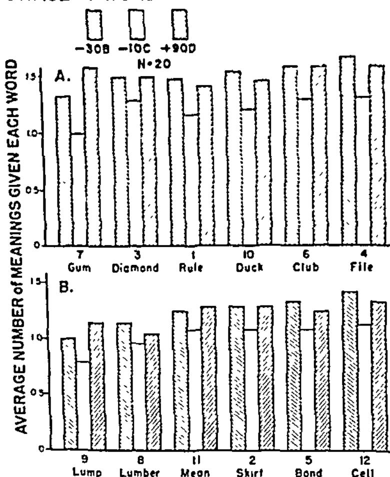


FIG. 51. The average number of definitions given to each stimulus word of the Homograph test by the 20 psychosurgery patients at 3 testing periods.

the frequency with which they elicited definitions at the -30B testing. It will be noted that the curve for +10C lies consistently below the curve for -30B and that the gap between these 2 curves increases as the frequency of definitions rises. Comparing the 6 words in Class A with the 6 words in Class B, it was evident that the easier words (those with high definition frequency) lost more definition categories at +10C than did the more difficult words. The difference was found to be statistically significant on the .05 level. This does not parallel Yacorzynski's ('41) hypothesis that the loss on verbal tests as a result

of deterioration, is largely a function of the difficulty level of the words, nor does it support the hypothesis that the loss is due to lowered intelligence. The present findings indicate that the losses after brain operation seem to be proportional to the initial frequency, difficult words losing definitions in no greater proportion than the easier words. In fact, there is a tendency for the easier words to suffer more than their proportionate share of the losses, although this difference of 17 per cent was not statistically significant.

The second question, namely, was there any tendency toward compensation by giving new definitions to replace the lost ones, really concerns itself with the identity of the definitions given 10 days postoperatively (+10C). Are these definitions a decimated residue of the preoperatively given definitions, or are there also some new definitions given to replace the older definitions lost in the immediate postoperative period? Figure 52 shows the average number of definitions lost and gained per word. The words are entered in order of number of definition categories lost at +10C.

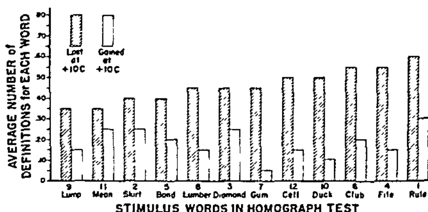


FIG. 52. The average number of definitions gained or lost by each stimulus word of the Homograph test by 20 psychosurgery patients 10 days after operation.

Although losses of old as well as gains of new definition categories took place at +10C, the number of new definitions did not make up for the losses. There was a tendency to compensate for the losses, but this tendency was not strong enough to compensate fully. It is interesting to note that the differences between losses and compensation increased as the average loss per word goes up. That is, there is a greater compensation tendency in the stimulus words which lost few definition categories than in those which lost many definition categories. This tendency may arise from 2 possible sources: (1) The operation may release the word meanings which had been inhibited preoperatively. If the failure to give more definitions was due to inhibition rather than lack of knowledge, the words which had few definition categories preoperatively might show an increase when inhibitory trends are removed. (2) Since the greater losses occurred in the stimulus words which elicited greater number of definition categories

originally, there were fewer new definition categories available to draw from postoperatively. Which of these 2 explanations is more tenable was not possible to determine on the basis of the available data.

The losses and gains in average number of definition categories per stimulus word by subgroups of patients are shown in Table 23. Of the 18.45 definitions per stimulus word given preoperatively at -30B,

Table 23

AVERAGE NUMBER OF DEFINITION CATEGORIES PER STIMULUS WORD RETAINED, LOST AND ADDED FROM THE -30 B TESTING TO THE +10 C TESTING

Operative Technique	N	Given at -30B		Lost at +10C		Added* at +10C		Net Loss at +10C	
		M	%	M	%	M	%	M	%
VL-I	4	20.75	100	10.50	51	1.75	8	8.75	43
VL-II	7	20.43	100	3.00	15	2.43	12	0.57	3
TO	7	15.71	100	4.71	30	2.29	15	2.42	15
TC	2	16.50	100	8.00	48	2.00	12	6.00	36
All	20	18.45	100	5.60	30	2.20	12	3.40	18

*Percentage based on number of definitions given at -30B.

5.60 or 30 per cent were lost at +10C and 2.20 or 12 per cent new definitions were added at that testing period, leaving a net decrease of 18 per cent.

The loss seemed to be lowest for the VL-II group, where an original loss of only 15 per cent occurred which was compensated for by 12 per cent new definition categories, leaving a net loss of only 3 per cent. The loss was also relatively light in the TO group where the original loss of 30 per cent was compensated for by an addition of 15 per cent new definition categories, leaving a net loss of 15 per cent. The high proportion of compensation in the TO group may be a reflection of their originally lower level, since the average number of definition categories in this group was 15.71, the lowest in any of the groups under comparison. The VL-II group which originally was as high as the VL-I group showed relatively little loss. This discrepancy between the 2 subdivisions of the VL group must be explained on some other basis than initial level differences, and may be a reflection of the

different severity or surgical procedures in the 2 groups. Our conclusion is that there is evidence in the immediate postoperative period of both loss and compensatory trends with the former exceeding the latter.

The third question deals with the final status of the preoperative definitions, namely, did the definitions given preoperatively eventually return, or did other definitions take their place? In most tests in which patients exhibited a decline followed by a return to previous level, it was difficult to differentiate between the relative importance of compensation and restitution of function. The process of finding several meanings to the stimulus items may be a varied one so that if one path to solution is not available another path may lead to a new definition. These are compensatory mechanisms which a patient may use if his usual method of solving a problem is interfered with. From the patient's answer to a test item nothing can be inferred about the process he chose for solving the problem. The units in most tests bear no identity and one can not trace changes in their value. The revised Homograph test offers more opportunity for determining whether the same process or a different process was followed in defining the words. To be sure, the same definition can be arrived at by different processes but one may assume that the giving of completely new definitions postoperatively probably involves different memory traces and pathways than those used in giving the preoperative definitions.

It is easy to determine the number of definitions that were restored and the number of new definitions given at any testing period. By referring to figure 51 we can see that generally the curve for the +90D testing parallels the -30B results, but we can not determine from this graph whether this restoration of level is due to compensation or to return of previously given definitions. Table 24 traces the course of the definitions given postoperatively. The groups as a whole regained all but 10 per cent of their initial definitions 3 months after operation. This would argue for a restoration of function rather than compensation. The restitution of definition categories was uniform for all subgroups except the VL-I in which 28 per cent of the originally given definitions failed to return.

What of the new words added at +10C? Did they persist at +90D? The data for these words are shown in Table 25. For the operated group as a whole only about 0.60 of the definitions given for the first time at +10C was retained at +90D. In group VL-I, none of the new words was retained; in the other subgroups from 20 per cent to 40 per cent was retained but since the original number of new definitions was so small, it may be concluded that the releasing of the new definitions immediately following the operation was not a stable phenomenon, much of the gains being lost in the 3-month period after the operation. This indicated the temporary nature of the compensatory effect in the immediate postoperative period.

At +90C some new definitions were given, but these contribute only 9 per cent of the number originally given at -30B. Apparently there was a slight tendency to gain new definitions, the majority of the

Table 24

LOSS AND RECOVERY OF THE DEFINITION CATEGORIES ORIGINALLY GIVEN AT -30 B, AND IN SUBSEQUENT TESTING PERIODS

Operative Technique	N	Given at -30B		Lost at +10C		Regained at +90D		Net Loss in Preoperative Definitions at +90D	
		M	%	M	%	M	%	M	%
VL-I	4	20.75	100	10.50	51	4.75	23	5.75	28
VL-II	7	20.43	100	3.00	15	2.57	13	0.43	2
TO	7	15.71	100	4.71	30	3.43	22	1.28	8
TC	2	16.50	100	8.00	48	7.00	42	1.00	6
All	20	18.45	100	5.60	30	3.75	20	1.85	10

definitions given at +90D were repetitions of the original preoperative definitions. The net gain at +90D for the entire operated group was 0.45 definition categories, (3 per cent of the initial number) indicating a complete reinstatement of the preoperative level. This return of level was not equal in all the subgroups. The VL-I subgroups showed a net loss of 4.75 (23 per cent) even at the +90D testing, indicating a real reduction in the initial fund of definitions.

WEIGL SORTING TEST QUALITATIVE ANALYSIS. Goldstein and Scheerer ('41) noted that organic patients show "an abnormal tendency to build patterns" in the Weigl test and that these patterns follow definite structural laws. Bolles ('37) in her comparison of a schizophrenic, mental deficient, and normal group of the same mental age found: (1) an ability to shift in both the schizophrenic and defective group, (2) a tendency for the defective group to perseverate on form, (3) a tendency for the schizophrenic group to perseverate on color, (4) a greater number of symmetrical designs and personalized arrangements in the schizophrenic group, and (5) inability of the defective group to verbalize their basis for sorting.

In the data of the present study a schematic representation was kept of each patient's sorting together with verbalization and related behavior. A tendency for designs and personalized patterning was noted in 55 per cent of the group before operation with no significant change in qualitative performance after operation. Various indices of differences in patterning effects were attempted but no consistent factor related to the operation could be isolated. The psychotic process, as noted by Bolles, appears to have a greater effect on patterning behavior than does organic brain damage.

Table 25

EFFECT OF NEW DEFINITION CATEGORIES ADDED AT THE VARIOUS TESTING PERIODS

Operative Technique	N	New Words Added at +10C		New Words Retained at +90D less +10C		New Words Added at +90D		New Words Added at +90D		Net Gain over -30B	
		M	%	M	%	M	%	M	%	M	%
VL-I	4	1.75	8	0	0	1.00	5	1.00	5	-4.75	-23
VL-II	7	2.43	12	1.00	5	1.71	8	2.71	13	2.29	11
TO	7	2.29	15	0.43	3	1.71	11	2.14	14	0.86	6
TC	2	2.00	12	1.00	6	3.00	18	4.00	24	3.00	18
All	20	2.20	12	0.60	3	1.70	9	2.30	12	+0.45	2

Our data do not substantiate Bolles' finding that the schizophrenic group tends to sort initially on the basis of color. In this population, form was used as an initial basis of sorting 53 per cent of the time before operation with no significant change after operation.

As already noted in the quantitative analysis, there was a statistically significant loss in ability to verbalize the basis for sorting. The following protocols illustrate this inability to form verbal concepts at the immediate postoperative period.

-30B	+10C	+90D
Case B2		
"All the same design, block, round triangle."	"They're all on the first floor, yellow on the first floor, red on second floor, Irish on third floor, English on fourth floor."	"According to shape."
"According to color."		"All the same color."
Case B3		
"Same colors together."	"Colors, shapes, sizes." (Repeated 6 times.)	"All the same colors together."
"Same shapes together."	"I did put colors, shapes, sizes together before, similar colors together. There's colors together."	"According to form."

REVISED HOMOGRAPH TEST QUALITATIVE ANALYSIS. Smith and Stein (unpublished) reporting on a comparison of brain-injured cases with psychotics and normals on the original Capps test proposed a discrimination score based on a ratio between the total number of correct different meanings and the total number of correct responses. They found that the brain-injured group gave a higher proportion of definitions which were but variations of the same definition category than did the other 2 groups. They hypothesized that the deficit was due to inability to recognize what constitutes a different meaning or a different definition category; that is, an inability to differentiate between similar definitions for the same word. In scoring the total correct definitions, there is some difficulty in deciding which of the meanings in the same definition categories are actually different responses and which are but elaborations of the same response. The data of the present study on operated cases do not agree with Smith and Stein's results on organic cases; the difference in the proposed ratios between -30B and +10C is 4.7 which is not statistically reliable. Only 9 cases out of 20 gave a greater proportion of meanings in the same definition category after operation.

A qualitative analysis of the language used in the revised Homograph test did not reveal any consistent characteristic attributable to the

operation. Here again the psychotic process seemed to be a more important determinant in the production of perseveration, bizarreness, and personalization.

One case, however, B6, produced a striking change in language at +90D which warranted further attention. This patient, classified as catatonic, throughout the testing periods was very cooperative although he displayed no spontaneity in language or motor behavior and no effective responses to the testing or the examiner. In the testing situation, his posture was rigid and his face immobile; he spoke in very low tones, with great difficulty answering in the fewest possible words. Although observation in the testing situation at +90D did not indicate much change, the following Homograph protocols reveal a marked difference in language.

Stimulus	-30B	+10C	+90D
Skirt	"To reconnoiter; material; slang for woman."	"To scout; part of dress."	"Household wear used by white working women; an amateur survey of an area perhaps; vulgar term describing a woman in fiction."
Diamond	"Baseball place; jewel."	"Jewel; baseball diamond; trade mark."	"A jewel; anything accepted as a trade mark or useful word in brief conversation; a stone; an alias name; valuable gem."
Bond	"A joining; life *bill of some* sort."	"A joining; a *testimony.*"	"Joining; a trade mark; *valuable; complicated* medium of exchange. Government service time of measuring *one's total investment* of service."
Club	"A bat for brutality."	"Rendezvous; to hit; a huge stick."	"A recluse; a weapon of ancient tribes; to club one in capital punishment; a trade mark of preferred food."
Gum	"Candy or sweetenings."	"Candy; to stop."	"To spoil the plan of one; candy used by confectioners—sold by them, new product manufactured; a chewing habit."
Lump	"A heaping; slang for chastizing; lump in the throat."	"A pile; a sore spot, that's all."	"A heaping; used as slang, emotional description; affection of good; form of moral essence of life."

There is certainly evidence here of greater spontaneity, a general "release effect" with some overideational verbal expression and perseveration. How much of this sort of change may be attributed to the operation, is, of course, not possible to state, but the effect produced here is in line with the reported results *of frontal lobe operations.*

DISCUSSION OF RESULTS FROM WEIGL AND HOMOGRAPH TESTS. The data obtained in this study indicate a definite test performance loss in the operated group shown 10 days after operation with a return to the preoperative level of function within 3 months. (Neither the 2 thalamotomy patients nor the non-operated patients followed this pattern.)

The explanation of the transient loss followed by recovery of functional efficiency has been given in a variety of ways by different investigators. The most frequent explanations are either "temporary blockage with subsequent resumption of function" or "compensation by acquiring new methods (or pathways) to replace those which were lost."

The Homograph test offers evidence relevant to these 2 explanatory principles, since the preoperative and postoperative scores can be analyzed into identical and non-identical units. If compensation takes place, it would be expected that the postoperative definitions would be somewhat different from the preoperative, since the new methods or pathways would probably not lead to identical definitions in the shift process. If restitution takes place, the definitions given after operation would probably differ but little from the definitions given before operation.

We found with the Homograph test that the recovery predominantly involved reacquisition (at +90D) of the identical definition categories originally given but lost (or unavailable) at 10 days after operation. Compensatory factors evidently played a very minor role. Interestingly enough, the evidence for compensation was clearest at +10C. The new definitions added at +10C were not fully retained at +90D when the original definitions were recovered.

Our data indicated that there is some transition stage in the immediate postoperative period where compensatory factors come into play, although not sufficiently to overcome losses, and that the individual returns to his preoperative level when a state of equilibrium has been re-established. The loss in "shifting ability" in the immediate postoperative period was equally evident in the less severe (transorbital lobotomy) as well as in the more extended operations (VL-II).

The 4 cases in the VL-I group showed a comparatively greater loss on the Weigl verbalization score, the Homograph shift score and the number of definitions lost, with only a partial return to their preoperative level on the latter 2. In this group, case B1 exhibited the greatest impairment at +10C with the least recovery at +90D. This relationship between extended posterior damage to the frontal lobes and lowered mental ability, also observed on the Verbal scale of the

operation. Here again the psychotic process seemed to be a more important determinant in the production of perseveration, bizarreness, and personalization.

One case, however, B6, produced a striking change in language at +90D which warranted further attention. This patient, classified as catatonic, throughout the testing periods was very cooperative although he displayed no spontaneity in language or motor behavior and no effective responses to the testing or the examiner. In the testing situation, his posture was rigid and his face immobile; he spoke in very low tones, with great difficulty answering in the fewest possible words. Although observation in the testing situation at +90D did not indicate much change, the following Homograph protocols reveal a marked difference in language.

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Bond	"A joining; life bill of some sort."	"A joining; a testimony."	"Joining; a trade mark; valuable; complicated medium of exchange. Government service time of measuring one's total investment of service."
Club	"A bat for brutality."	"Rendezvous; to hit; a huge stick."	"A recluse; a weapon of ancient tribes; to club one in capital punishment; a trade mark of preferred food."
Gum	"Candy or sweetenings."	"Candy; to stop."	"To spoil the plan of one; candy used by confectioners—sold by them, new product manufactured; a chewing habit."
Lump	"A heaping; slang for chastizing; lump in the throat."	"A pile; a sore spot, that's all."	"A heaping; used as slang, emotional description; affection of good; form of moral essence of life."

twice postoperatively; one postoperative test was given 10 days and the other 3 months after operation. The Wechsler-Bellevue Form I was also used twice preoperatively and twice postoperatively; one postoperative test 3 months and the other 4 months after operation. In a 6 month follow-up, Form II was administered.

The results of this study gave no evidence for a permanent deficit below initial preoperative level on any of the psychometric procedures. The data clearly indicated 2 postoperative changes: (a) a temporary loss in the immediate postoperative period on the Porteus, Homograph, and Weigl tests, and (b) a difference in rate of improvement in test performance after operation between the operated and non-operated groups on the Wechsler-Bellevue Performance scale.

The temporary loss was equally evident in the less severe (transorbital lobotomy) and in the more extended operations (venous ligation). The recovery at 3 months on the Homograph test was due to the reacquisition of identical definition categories originally lost in the immediate postoperative period.

Four patients with a more extensive posterior involvement of the frontal lobes showed a comparatively greater deficit in the immediate postoperative period on the Porteus Maze, Weigl verbalization, and Homograph shift scores and only partial recovery at the end of 3 months on the latter 2 tests. They also showed a decline on the Wechsler-Bellevue Verbal scale up to 6 months after operation.

The inability to benefit from practice, which persisted up to 6 months after operation on the Wechsler-Bellevue Performance scale, may arise from the following possible sources, among others: (a) lowered interest and motivation, (b) lowered ability to learn, and (c) lowered basic capacity. Which of these sources was primary could not be determined on the basis of the present data.

The results on the psychometric procedures of this study gave no evidence for a permanent deficit below initial preoperative level.

There are 2 postoperative changes which were clearly indicated by our data: (a) a temporary loss in the immediate postoperative period on the Porteus, Homograph, and Weigl tests, and (b) a difference in rate of improvement in test performance after operation between the operated and non-operated groups on the Wechsler-Bellevue Performance scale.

The temporary loss was equally evident in the less severe (transorbital lobotomy) and in the more extended operations (venous ligation). In the immediate postoperative administration of the Homograph test, it was possible to demonstrate the appearance of some compensatory effects during the period of physical recovery from the surgery. By 3 months after operation there was a reacquisition of identical definition categories originally lost in the immediate postoperative period. There does not appear to be any permanent reduction either in the preoperative level of performance or in the manner of performance. Our general conclusion must be that this pattern of change is independent of the particular operative procedure utilized and is but a reflection of temporary physiologic changes in the brain.

Wechsler-Bellevue test, is supported by a number of other studies (H. E. King, '49, and W. R. King, '49).

WEIGL AND HOMOGRAPH SUMMARY AND CONCLUSIONS. 1. All operated patients followed a similar pattern of change on both the Weigl and Homograph tests; namely, a gain between the first and second preoperative testing periods, a loss in the immediate postoperative period and a recovery within 3 months. The changes between testing periods for the operated groups meet the statistical criteria for significance. Neither the control nor thalamotomy patients showed a loss in the immediate postoperative testing period. Various qualitative indices of patterning performance in the Weigl test, and language expression in the Homograph test did not reveal any consistent difference attributable to the operation.

2. The 4 cases within the group who had extended posterior interference in the frontal lobes (VL-I) revealed a relatively greater loss on verbal tests in the immediate postoperative period with only partial recovery over 3 months.

3. From a quantitative analysis of the different definition categories lost and gained after operation on the Homograph test, the following considerations have been advanced: (a) There was no differential loss evident in the more difficult definition categories. The hypothesis is suggested that the operation did not interfere with the ability to define words, that is, with a general intellectual factor, but, rather, with the mechanism underlying the ability to shift a mental set. (b) The return to a preoperative level within 3 months involved the reacquisition of the same definition categories originally lost or unavailable in the immediate postoperative period. It was not possible to attribute this recovery in test performance to compensatory factors. Some compensatory effects were observed in the immediate postoperative period; that is, new definition categories were added at this time, but these were not retained in the later testings.

4. It is concluded that one of the immediate effects of a frontal lobe operation, employing the operative techniques of this study, is a deficit in shifting ability, both on a performance level, as measured by the modified Weigl test, and on a verbal level, as measured by the revised Homograph test. These losses are regained by most patients within 3 months.

GENERAL SUMMARY AND CONCLUSIONS

Two standard intelligence tests, the Wechsler-Bellevue Forms I and II and the Porteus Maze, and the Weigl and revised Homograph tests in the area of sorting and shifting ability, were given to a group of 28 patients. Twenty-two patients in this group underwent psychosurgery (venous ligation, transorbital lobotomy, thermocoagulation, and thalamotomy), while 6 served as controls. The Porteus, Weigl, and Homograph tests were administered twice preoperatively and

Chapter 10

COMPLEX MENTAL FUNCTIONS: MEMORY, LEARNING, MENTAL SET, AND PERCEPTUAL TASKS

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Among the clinical claims that have been made concerning the function of the intact frontal lobes are that within them are "centers" in which are organized perception and learning processes, together with the maintenance of direction of activity and goal seeking. Presumably, injury or surgical ablation of parts of the frontal lobe should lead to interference with these functions. Previous experimental studies of brain tumor and psychosurgery patients yielded no substantiation of these claims, but they still persist in many quarters partly because of the long tradition behind them and partly because it is much more difficult to disprove a hypothesis experimentally than to propose one. It is clear that pure tasks of each of these capacities can be constructed only with great difficulty since perception and learning enter into almost all mental tasks, and maintenance of set is a factor in all mental activity. Nevertheless, tasks can be found that may be regarded as dependent primarily on learning and relatively free of other psychologic functions. Similarly, tasks can be found for testing perception and mental set that are relatively free of other functions.

More than 10 tasks were developed to sample the areas of learning, memory, mental set, and perception. In general, new tasks not previously included in earlier studies were selected or developed and the leads provided by these studies served as a guide. Each of these areas of investigation will be described separately.

The tests were administered approximately 10 days before operation and again about 90 days after operation. The preoperative data are designated as -10A and the postoperative data as +90B. It had been intended to retest the patients several times before operation so as to be able to estimate the degree of intraindividual variability to be expected from mere repetition of a test, but this could not be done for a variety of reasons. After operation, too, it did not prove feasible to test the patients more than once. Since it was not practicable to prepare comparable forms of each of the tests for postoperative administration, the tests used preoperatively were repeated. This introduced the uncontrolled variable of familiarity with the test as well as practice effects, but it seemed safer to run this risk than to utilize new tests.

The composition of the patient group varied for the different tests,

A comparison of the operated and non-operated group at the 3 months postoperative testing on the Porteus, Homograph, and Weigl tests indicated that the operated patients, although restored to their preoperative level, may not have gained as much from practice as the non-operated patients. There was a small but consistent difference in practice gains between these 2 groups.

The administration of Wechsler-Bellevue, Forms I and II, at 3, 4, and 6 months after operation consistently indicated a decrease in the ability to profit from practice on the Performance scale for the operated patients as compared with the non-operated group. This decrease in ability to benefit from practice which persisted up to 6 months after the operation, may arise from the following possible sources, among others: (a) lowered interest and motivation; (b) lowered ability to learn; (c) lowered basic capacity.

If lowered interest and motivation were the cause of the decrease in ability to profit from practice, the Verbal as well as the Performance scales would be affected. A comparison of the curves for the Performance and Verbal scales (figures 48 and 49) indicates quite clearly a greater practice effect operating in the Performance scale. If the operation interferes simply with an "ability to profit from practice," that is, with a learning function, it would naturally effect the scores which are more amenable to practice. The second hypothesis (that there was a lowering of ability to learn from the repeated application of the test) seems tenable in the light of this consideration.

On the other hand, the inability to profit from practice may be a reflection of a lowered capacity, that is, a reduction in potential achievement level, in some function measured by the Performance scale. According to this hypothesis, the basic capacity of the patient has been reduced to such a point that the continued postoperative practice can not raise him to as high a level as he might have reached, had not the operation intervened.

It is not possible with the data available, to reach any definitive conclusion regarding these alternative hypotheses. This study does indicate that the operated patients have been changed in their ability to improve with practice, and that this change persists for at least 6 months postoperatively.

The first 4 cases in the venous ligation group underwent a more extensive posterior involvement of the frontal lobes. These patients showed a comparatively greater deficit in the immediate postoperative period on the Porteus Maze, Weigl verbalization, and Homograph shift scores and only partial recovery at the end of 3 months so far as the latter 2 tests are concerned. They also showed a decline on the Wechsler-Bellevue Verbal scale for 6 or more months after operation. Hence, we conclude that the data of this study indicate a relationship between extended damage to the more posterior portions of the frontal lobes and decreased efficiency in test performance.

cerebral ablations has seldom been tried with patients. The technique adopted in the present study utilized 6 wooden boards, on each of which were fastened 12 playing cards. Six were aces and 6 were nines and tens. The cards were placed in random order so that no 2 boards were alike. Each playing card was covered by a piece of stiff, gray cardboard hinged to the wooden board so that the playing cards could be exposed by lifting the lid for a brief exposure.

The patient was seated in front of the first board and instructed as follows:

> Beneath these cover lids are playing cards. There are aces, and nines and tens. I am going to show you the aces and I want you to remember where they are.

The examiner exposed the first 2 aces and asked the patient:

> Show me the first ace I showed you; just the first one.

After the patient indicated the first ace, the examiner exposed the third ace. The patient was then asked to show the examiner the second ace that had been exposed. The examiner kept one ace ahead of the patient. This procedure was followed for the first 2 boards. If the patient was successful with this part of the experiment, he was given 2 more boards. This was essentially the same as the single delay sequence, except that the examiner allowed a lag of 2 aces between the patient's uncovering and his own. If the patient completed this, the examiner continued with triple delay, allowing a lag of 3 aces between the patient's uncovering and the examiner's exposure. In this manner, the nature of the delay was graded in difficulty. Each ace was exposed for approximately 2 seconds.

VERBAL DIRECTIONS. One of the important elements in efficient social interaction is the capacity for understanding directions for carrying on everyday activities. In the first Columbia-Greystone project (Stauffer, '49), this type of test was used as a learning task to see how many repetitions were required before an entire set of directions could be mastered. The results indicated that the ability to learn such directions and to retain them was not impaired by topectomy. In the present study, this test was used not as a learning task but as a means for testing immediate comprehension and retention.

A list of simple directions was read to the patient and he was asked to repeat it. Credit was given for the recall of a memory item even when the patient did not repeat verbatim the original words, provided he recalled their intended meaning. The following directions were given:

> I am going to read you some directions on how to do certain things. Listen carefully and then repeat the directions in your *own words*. *For example*; here are the directions for "Going to the movies": (1) Go to the ticket booth, (2) Ask for a ticket, (3) Pay for it, and (4) *Give* it to the ticket collector as you walk in.

and for this reason the patients included in each test procedure will be described for each test.

THE TESTS

Memory and Learning

Retention of learned material over extended periods (3 weeks to 3 months) was studied exhaustively in the first Columbia-Greystone project (Stauffer, '49), but the function of immediate memory was touched upon only lightly. In the present study immediate memory was subjected to closer scrutiny. The tests used were: (1) incidental memory, (2) sequential delayed reaction, (3) verbal directions, and (4) the learning task.

INCIDENTAL MEMORY. It seems likely that the grosser features of memory functioning are usually untouched by frontal lobe surgery but that the more subtle aspects of memory such as incidental memory or span of memory might be impaired. Thus an operated patient may be able to recall material to which his attention had been directed but might be unable to recall the more incidental memories which accompanied the perception of objects or events in the focus of his attention. In order to examine incidental memory the following technique was utilized. A picture was exposed for 2 seconds after the patient's attention had been directed to a special feature in the picture. Then he was asked to recall not only the special feature to which his attention had been directed, but also several other incidental features which had not been called to his attention. Two pictures were used: (1) Chinese Grandfather, Son, and Grandchildren (Perry, '40) and (2) Card *No. 2 of the Thematic Apperception Test (Murray, '43).* The directions for the first picture were as follows:

> I am going to show you a picture for a short period of time. Look at it carefully because when I take it away I am going to ask you how many people you saw in it.

After a 2-second exposure, the patient was asked how many people were in the picture. In addition to this, he was asked how many children and how many adults were in the picture. He was also asked to tell whatever else he could remember. The second picture was presented after a brief interval. The directions for the second picture were similar to those given for the first except that the patient's attention was directed to what the people were doing and the incidental memories dealt with the number of men and women in the picture and whatever else he could recall.

SEQUENTIAL DELAYED REACTION TEST. The delayed reaction experiment which has been investigated in animal experimentation on

correct successive repetitions. The syllables were learned in a serial order by the anticipation method under massed practice conditions. They were mounted on a continuous paper band on a memory drum and were presented in pica type capital letters on heavy paper. They were exposed through a window 6 cm × 1 cm. Bright illumination without glare was provided by a light behind the patient. At each preoperative testing session the patient was presented first with a practice list of 4 syllables. This was followed by a forced tempo list of either 4 or 6 syllables, and finally by a similar free tempo list. The practice list, which consisted of genuine radio stations in the New York area, was given to acquaint the patient with the task, and to supply the examiner with a gross estimate of the patient's learning ability. On the basis of this information, lists of either 4 or 6 units were utilized in the main experiment. At each postoperative test session, too, the patient was first presented with the practice list. Then the free tempo list was given, followed by a forced tempo list. (The order of free and forced tempo was reversed from the preoperative test to the postoperative test.)

The following directions were given for the practice list:

> I would like to see how quickly you can learn the names of the radio stations in New York. Read the names as they appear in the window.

The examiner then demonstrated how the memory drum operated and instructed the patient to anticipate the syllables before they appeared in the window. If the patient was able to anticipate this list correctly to the criterion of 2 successive errorless repetitions in 20 trials or less, he was given a 6 syllable list in the main experiment; if he required more than 20 trials, he was given 4-syllable lists.

After the practice list was learned, the patient was instructed:

> *Now I want to see how fast you can learn a list of radio stations for the* city of Boston. Read the names as they appear in the window.

Each syllable was exposed for a 6-second interval, and was followed immediately by the next syllable. Between successive presentations of the list there was a 12-second pause.

After forced tempo learning was accomplished to a criterion of 2 correct successive repetitions of the list, the patient was instructed:

> This time we are going to do it differently. You can move the list yourself...(Examiner demonstrated manual mechanisms)...Read each station as it appears in the window and then press down on this bar to get the next station. This is a list of the radio stations from the city of Chicago.

This was continued until the patient mastered the list to a criterion of 2 correct reproductions in sequence. (The investigators are indebted to Mr. Charles Lothridge for his assistance with this part of the experimental program.)

If the patient could not repeat the above directions or recalled only one item, he was given another set of simple directions on "Sharpening a pencil." If these 2 were failed, the test was terminated and recorded as a failure. If the patient succeeded in the first set of directions, the examiner proceeded to the main experiment which consisted of 2 sets of directions, one for "Ordering an overcoat" and the other on "Learning how to swim."

LEARNING TASK. In the first Columbia-Greystone project an attempt was made to study meaningful and semi-meaningful material to see whether psychosurgery affected the learning of the various materials differentially. No striking changes were noted in this respect. The present study was limited to semi-meaningful material and dealt with the more intricate aspects of learning rather than the grosser aspects covered in the previous study. Instead of the paired associate method utilized previously, serial list learning was chosen as the learning task. This has the advantage of requiring greater interitem organizing ability on the part of the subject and of permitting a closer analysis of the learning process with special reference to the effect of serial position, retroactive, and proactive interference, and other learning phenomena which can be measured directly. In order to render the task as meaningful as possible for the patient, the lists consisted of the names of pseudo radio stations in various cities. The pseudo radio stations technique has several advantages. First, it provides a quasi-meaningful approach which the patients accept readily. Previous attempts at teaching mental patients nonsense syllables proved it to be a task for which the patients were insufficiently motivated, whereas the radio station idea seemed to appeal to them. Secondly, the syllables are spelled rather than pronounced, thus removing differences in pronunciation as a possible source of error in recording the learning process. The use of spelled rather than pronounced syllables was introduced by Witmer ('35), who has determined the associative value of 4534 3-letter nonsense syllables constructed from 19 consonants of the alphabet. In the present study only syllables with a 50 per cent association value in Witmer's list were included.

Since several studies (Ach,'35) have shown that some types of individuals respond differently to tasks in which the tempo of work is more or less under their spontaneous control, in contrast to those in which the tempo is fixed by external means, the learning task was administered under these 2 conditions of spontaneous or "free" tempo vs. "forced" tempo. For the "forced" tempo a memory drum was used in the standard fashion with a 6-second interval between exposures, while for the "free" tempo the patient himself actuated the memory drum by means of a microswitch which could be pressed down to move the drum to the next position.

The method utilized in this experiment was to have the patient learn a list of either 4 or 6 pseudo radio stations to a criterion of 2

of "unresolved tensions." The procedure was to give the subjects a series of tasks, about half of which were permitted to go on to completion while the other half were interrupted. There were at least 3 ways of measuring the effect of the interruption: (1) recall method, (2) resumption method, and (3) substitutive method. The recall method consisted essentially of having the subject attempt to recall the entire series of both completed and incompleted tasks. He usually recalled the incompleted tasks more frequently. The resumption method consisted of exposing the subject, after the interruption had taken place, to the materials of both the interrupted as well as the completed tasks to see which type of task was resumed. Here again the incompleted task had the advantage. The substitutive method of Lewin presented a new task immediately after the interruption to see whether the "unresolved tension" would expend itself on the substitute material. The specific method utilized in this study was the resumption technique.

The patient was given a simple 25-piece jigsaw puzzle. When the puzzle was half completed, it was taken away and the patient was given some of the pieces of the Lowenfeld Mosaic test (Kerr, '39) and asked to make a design. He was told that he might use as many pieces as he liked and might make any kind of design he wished. The incompleted jigsaw puzzle and a deck of playing cards were placed within reach on the table. After the patient had completed the mosaic design to his satisfaction, the examiner told him that he might do anything he liked while waiting for the next task, because the examiner had to complete his notes. (The examiner had been taking notes throughout the procedure.) If the patient did not resume the puzzle after 2 minutes he was reminded that he might do anything he liked. If he did not resume after 5 minutes the experiment was terminated.

DIRECTIONAL SET. (Street Map Mazes.) One characteristic feature of some schizophrenic and neurotic patients is the degree of rigidity or inflexibility they exhibit in performing simple tasks. This type of rigidity leads to stereotyped behavior which is characterized by the maintenance or adoption of mental sets that are not suitable to the task at hand. Many of the chronically ill patients included in this study exhibited this form of stereotypy during the period of preoperative testing. We wished to determine whether such behavior would be disturbed by the various operative procedures and whether patients who did not exhibit such stereotypy might begin to exhibit such behavior after psychosurgery. In order to examine these phenomena experimentally an attempt was made to establish a fixed directional tendency in the patient. Then the degree of pressure required to alter this directional tendency, or to break the previously established set was measured.

The patient was given a series of mazes, set up as street maps and was instructed as follows:

> I am going to show you some street maps. At the bottom of each one you will see a car. You are to drive the car to the park. You must remember that you should stop at the stop sign and that you cannot go through a dead-end street. Trace the route that you would take to get to the park.

Mental Set

Mental set has been defined as a condition of readiness for some specific type of mental performance. A mental set can be initiated either spontaneously or in response to someone's command or request. It may be temporary or it may last for a longer period. Furthermore, a mental set may involve such tasks as sorting, in which a categorical attitude is required for correct performance, or it may involve simpler activities such as counting. Since an individual in the waking state is rarely completely inactive, the initiation of mental sets usually involves a shift from a previous set to the new one. Goldstein ('36), among others, has expressed the opinion that mental set depends on the integrity of the frontal lobes. For such reasons an attempt was made in this study to examine some of the mental set phenomena which had not undergone close scrutiny in the first Columbia-Greystone study.

The tasks for measuring mental set utilized in this study were as follows: (a) interrupted set (counting and reciting the alphabet and names of the months), (b) interrupted task, (c) directional set (street map mazes), (d) the word selection set, and (e) the sustained task technique (Kraepelin, '25), in which the patient is required to add continuously for a 15-minute period. Each of these set experiments will be taken up separately.

INTERRUPTED SET. (Counting and reciting the alphabet and the names of the months.) In this task, which requires the ability to maintain a set in the face of distracting circumstances and to shift from one set to another, the patient was instructed as follows:

> I'd like you to start counting aloud, 1, 2,...Stop. Now I'd like you to recite the letters of the alphabet, A, B,...Stop. Tell me the months of the year, January, February,...Stop. Now I want you to start counting again where you left off last time...Stop. Tell me the letters of the alphabet starting with the letter you left off with last time...Stop. Now tell me the months of the year starting with the month you left off with last time... Stop.

The counting was continued for 7 to 11 digits each time and the alphabet and month recitation was continued for an equal series. When the end of the alphabet was reached the patient was told to begin over again with A, and similarly when the end of the months was reached he was told to start over again with January. This change from numbers to letters to months was repeated 3 times at each testing period.

INTERRUPTED TASK. The interrupted task technique has been utilized on both normal subjects and mental patients. In general it tends to differentiate between these 2 groups. Ach ('35) has explained the effectiveness of the interrupted task on the basis of his "will" theory, while Lewin ('35), *who originated the method, explained it on the basis*

is their lack of capacity to maintain efficiency in a prolonged task. While tasks of short duration may not reveal a difference between normals and mental patients, a task continued for a long time is likely to show a much greater decrease in the patient than in the normal individual. The task utilized in this study was the same as that utilized by Kraepelin, namely, continuous addition of simple numbers. The purpose of this technique was to determine whether the frontal lobe operations tended to alter the efficiency of mental patients in long continued tasks. H. E. King ('49), after applying the "Continuous problem task" which involved the learning of complex positional light patterns, concluded that there might be a deficiency in this function in the topectomy patients. Instructions were given the patient as follows:

> I want to see how fast you can add. When I say "Ready, go"...begin to add these figures as fast as you can and continue until I tell you to stop. When you come to the end of one page do not stop, but go on to the next page. Ready, go.

The patient was given a soft pencil with an eraser. Constant bright illumination without glare was furnished by a floor lamp stationed behind and to the left of the patient. The examiner's stopwatch was concealed from the subject.

A notation was made of the patient's progress per minute in terms of his position on the additions sheet, from which a minute-by-minute work curve was later obtained. The test continued for 15 minutes.

The patient was then presented with 5 sheets of 2-digit addition problems, each sheet containing 90 additions in which the patient had to "carry" from the first to the second column. "Carrying" was introduced to note whether the extra effort involved would tend to introduce errors as the work continued. The patient was instructed as follows:

> Now I would like to see how fast you can work adding these figures. Add the problems on these pages as quickly as possible.

Notation was again made of the progress per minute. This test continued for 5 minutes.

Perceptual Tasks

The first Columbia-Greystone study had utilized the following projective techniques; the Word Association test, the Rorschach test, and the Levy Movement Blots. No demonstrable changes occurred in the word association test as a result of the operation. The Rorschach test performance was analyzed individually as well as statistically but only one significant finding emerged, namely, the reaction time to the first response was reduced.

In the first series of 5 mazes, the only correct solution was to turn to the right. The next series of mazes was basically similar in design to the first, but it gave the patient the opportunity to break the set spontaneously. He could take the previously established route to the right, or take the shorter route to the left. He was then given a third series of mazes, where the only correct solution was to take the left, or the shorter route. The patient was thus forced to break his previous set in this last series of mazes, if he could not break it spontaneously in the second series of mazes.

WORD SELECTION SET. One method of testing the capacity of maintaining a mental set is through the controlled word association technique. In this technique the patient is given the set to respond with antonyms or synonyms or some other type of association when the stimulus word is presented. An adaptation of this controlled association method was made to set the level of functioning of the chronically ill mental patient studied in this investigation. In order to remove any obstacles to response arising from unfamiliarity with the stimulus words, only words of the Thorndike A level (Thorndike and Lorge, '44) were used. Instead of the more difficult task of supplying the correct association to the stimulus word, the patient was asked to recognize the correct response from a pair of words presented tachistoscopically. There were 3 levels of the task; the single set, double set, and triple set. In the single set, the patient was required to select from the pair of exposed words the word that designated part of the body. The pairs of words (one distractor and one correct choice) were presented tachistoscopically first at an exposure of 10 milliseconds. This was done 3 times and then the time of exposure was increased stepwise to 20, 40, 100, 200, 500, and 1000 milliseconds until the patient made a correct selection in accordance with the set established by the instructions. The double set consisted of selecting out of the pair of words the one word which designated either a part of the body or a food. Only 2 words were flashed on the screen (a distractor and the correct choice) and the exposure intervals were the same as for the single set. The triple set consisted of directions to select the one word in the pair which designated either a part of the body, food, or color.

A record was kept of the exposure interval at which the correct choice was made, and whether it was the first, second, or third exposure at that interval. The degree of certainty of each judgment was estimated by a rating ranging from complete uncertainty to complete certainty in 3 steps. The various misrecognitions which were given by the patient before he recognized the word correctly were also noted. In this way it was possible to measure the ability of the patient to maintain a single set, double set, and triple set.

THE SUSTAINED TASK. Kraepelin ('25) showed that one of the distinguishing characteristics of mental patients, especially schizophrenics,

incidental items to which the patient's attention had not been called, 2 scores were available. Standards for these 2 scores were established on the basis of the preoperative data. The modal response to each question was accepted as correct. Thus, a response of either "7" or "8" persons was accepted as correct for the direct memory item to Picture I, while answers in excess of 8 or below 7 were scored as errors. Responses of "3" or "4" children were accepted as correct for the indirect memory item. Similarly, the answers such as "farming" or "cultivating" were accepted as correct for the direct item to Picture II, and "one or 2 men" and "one or 2 women" were accepted as correct for the incidental items in the picture. Any response that differed from the standard was scored as an error. The number of errors in the 2 contrasted groups, operated or control, is shown in Table 26 for the direct and incidental items combined, since no differences were obtained between them.

Table 26

TOTAL NUMBER OF ERRORS IN THE TEST OF INCIDENTAL MEMORY IN THE OPERATED AND CONTROL GROUPS

		Testing Periods		
Groups	N	-10A	+ 90B	Total
Operated	14	9	9	18
Control	4	2	4	6
Total	18	11	13	24

It may be concluded that as far as immediate memory is concerned, of both the direct and incidental types, no significant changes attributable to psychosurgery were demonstrable. This test was in the process of development during the preoperative test sessions. Conditions under which it was administered and the directions for giving the test were modified and revised. Because of these modifications in administration there are too few comparable cases. It is felt, however, that the rationale is essentially a sound one, and that with more standard presentation methods, this easily administered test might prove to be a valuable tool.

SEQUENTIAL DELAYED REACTION. There were 23 patients in this experiment; 19 were in the operated group and 4 were controls. All of the patients were tested 2 weeks preoperatively and 3 months

DIGIT PERCEPTUAL SPAN AND WORD RECOGNITION TEST. The word association technique was modified so as to remove certain of the difficulties which might interfere with the analysis. The important element in the word association technique for our purpose was the stimulus word, which we thought might prove to be either of neutral or emotional significance for the patient. In previous studies neutrality or emotionality was judged by examining the type of response given; that is, whether it was an expected or unexpected word, whether it had a long or short reaction time, or whether it showed any other indications of being complex-bound. The difficulties inherent in making such judgments were thought to militate against an accurate evaluation of the results. Since the emotional tone is set off by the stimulus word, it might be better to study the impact of the stimulus word directly rather than through the response word which is elicited.

One way of studying the emotionality that attaches to the stimulus word is to determine its ease of recognition under tachistoscopic conditions. Presumably a word that is emotionally charged may require a longer time for recognition. One study (Bruner and Postman, '47) utilizing this method indicated that, in college students, words which seem to be emotionally tinged tend to have longer recognition times and give rise to many misrecognitions during the trial-and-error period. The manner in which a subject misrecognizes a given word sometimes indicates the emotionality that attaches to the word. This technique was adapted to the need of the patients in the following manner: first, the digit span of the patient was determined by exposing one-digit, 2-digit and 3-, 4-, or 5-digit numbers at 10 milliseconds. This served both as an introduction to the perceptual tasks as well as a means of determining perceptual capacity. Then a series of neutral words selected from the Kent Rosanoff list was presented one at a time at a 10-millisecond exposure. Each word was shown 3 times in succession and the time required for response, the actual response given, and a judgment as to certainty of response was recorded. If the subject failed to recognize the word correctly the procedure was continued with longer exposures of 20, 50, 100, 250, 500, and 1000 milliseconds with 3 exposures at each interval until the patient made a correct recognition of the word. A similar list of emotional words selected from the Orbison list (Rappaport, et al., '46), and a list of words culled from the patient's case history on the basis of their likelihood of arousing complex-bound associations was also used.

RESULTS

Memory and Learning

INCIDENTAL MEMORY. The incidental memory test was administered to 18 patients preoperatively, 14 in the operated group and 4 in the control group. Since the test contained 2 aspects of immediate memory, a direct item to which the patient's attention had been called and

Table 28

NUMBER OF MEMORY ITEMS RECALLED ON THE VERBAL DIRECTIONS TEST BY THE OPERATED AND CONTROL GROUPS

Group	N	Form A (Overcoat Order) Pretest	Post-test	Gain	Form B (Swimming Lesson) Pretest	Post-test	Gain
Operated	16	8.6	9.6	+1.0	7.9	7.6	-0.3
Controls	4	7.3	9.8	+2.5	10.5	10.3	-0.2
Total	20	8.3	9.6	1.3	8.4	8.1	-0.3

effects, Form A showing a gain of 1.3 points while Form B showed no gain. It is interesting to note that the control group gained 2 1/2 times as much as the operated group on Form A, but because of the small number of patients in the 2 groups no valid statistical comparison could be made. Nevertheless, the material interested the patients and was responded to adequately by those whose capacity was equal to the task. If it is to be used in future work of this sort it should be revised, expanded, and extended.

LEARNING TASK. There were 9 patients on whom sufficient records were obtained, 7 operated and 2 controls. The means for the -10A testing and the +100B testing for the forced and the free procedures are shown in Table 29.

Table 29

MEAN NUMBER OF TRIALS REQUIRED FOR LEARNING BY THE FREE AND FORCED PROCEDURES

Group	N	Forced Tempo -10A	+100B	Difference	Free Tempo -10A	+100B	Difference
Operated	7	20.7	15.9	4.8	15.9	16.9	-1.0
Control	2	10.0	9.0	1.0	6.5	4.5	2.0
Total	9	18.3	14.3	4.0	13.7	14.1	-0.4

postoperatively. The records were scored in terms of errors in identifying the aces. Every time the patient uncovered a card that was not an ace an error was registered on his record. The data are shown in Table 27. In general, no striking differences were obtained from the

Table 27

AVERAGE NUMBER OF ERRORS IN THE SEQUENTIAL DELAYED REACTION TEST BY OPERATIVE GROUPS

Operative Technique	N	Testing Periods -14A	+90B	Difference
VL	10	2.08	1.92	0.17
TO	5	3.06	3.30	-0.26
Other	4	2.33	2.49	-0.16
All	19	2.37	2.40	-0.03
Control	4	1.24	2.21	-0.97

preoperative to the postoperative testing. Both the operated group and the control group showed a slight tendency to make an increased number of errors in the second testing session. The group of venous ligation patients showed a contrary trend, however, their errors decreasing slightly in number postoperatively. Because the technique was not standardized until later, and because of the possible effects of interexaminer differences, these observations should be regarded as only tentative.

The ability to perform sequential delayed reaction problems, as measured by the materials used in this experiment, was not at a very high initial level in these patients. The variability in the results, and the lack of consistency within the operated groups, make it difficult to interpret the losses and gains in terms of the operative procedures. If this test is to be used in future research both the test materials and method of procedure should be changed.

VERBAL DIRECTIONS. This test was administered to 20 patients; 16 operated cases and 4 controls. Since the 2 repetitions of each test yielded approximately similar results, the sums of the items recalled on both repetitions were totalled and considered as one score. The average number of items recalled on the 2 forms of each test is shown in Table 28. The 2 tests differed in their susceptibility to practice

of the year was noted and a total error score obtained for each patient. Since there were 2 interruptions in each task, the maximum possible number of errors for each of the tasks was 2, or a total of 6 for the 3 tasks combined. Whenever the patient resumed the counting at or near the point which he had reached when he was interrupted, the performance was considered satisfactory. If, however, he lost his place completely or started at a point 2 or more digits (or letters or months) away from the stopping point, it was regarded as an error. The mean number of errors in the operated and control groups is shown in Table 30.

Table 30

NUMBER OF ERRORS IN THE INTERRUPTED SET

Group	N	-10A	+90B	Difference
Operated	14	1.71	1.63	-0.08
Control	4	2.00	0.75	-1.25
Total	18	1.78	1.45	-0.33

There was a definite improvement due to practice in the control group, but the operated group as a whole did not show such improvement. Analysis of the performance of the venous ligation group of 8 patients indicated that they showed relatively more practice effect than did the control group. The transorbital group of 4 patients showed a tendency not to benefit from practice.

There were some operated and some control cases in which performance in this task improved slightly at +90B testing, and there were also some operated and some control cases in which performance was poorer at +90B. In no case was there evidence of gross improvement or gross deterioration in this test, nor was there a significant difference between the control and operated groups.

In view of Malmo's ('47) report of a similar technique applied to one psychosurgery patient we had expected this test to be of greater usefulness than it was. In contrast to his finding of a large increase in errors postoperatively, our patients showed a decline in number of errors.

With regard to the use of this test in future work it seems doubtful that it will ever serve in its present form as a profitable part of a test battery since patients usually perform the task quite well initially and little opportunity is left for subsequent improvement. Hence, it can prove useful only for very deteriorated patients.

The forced procedure seems to show a greater practice effect than the free and this was especially marked in the operated group. In the free procedure the operated group shows a slight loss while the control group shows the normal effects of practice.

Clear-cut interpretations of these data are difficult to make in view of certain deficiencies in the experimental design and other testing irregularities, namely:

1. No second postoperative retests were given. This was contemplated in the original design of the experiment (but not carried through) in order to evaluate the influence of the mutual interaction between forced tempo and free tempo lists by alternating the sequence of presentation. Consequently the effects of the operation are confounded with the forced-free effect.

2. The same lists were given preoperatively and postoperatively to assure a constant level of difficulty of material, but this also confounds the variables of remote retention and learning ability.

3. All scores were recorded in terms of number of trials, but since the patients controlled the rate of syllable presentation of the free tempo procedure, this measure does not accurately reflect the speed of learning. It would have been desirable to record the time required for free learning in addition to the number of trials.

4. Some patients were given lists consisting of 6 syllables, while other patients were presented with 4-syllable lists because it was found that they could not master the 6-syllable lists within a reasonable number of trials. In comparing the results of the 4- and 6-syllable lists certain extrapolations had to be made, the validity of which is questionable. There is no consistent significant change from before to after surgery in the relative difficulty of the syllables within the lists. Thus, we find no support for the contention that brain-operated cases show a greater susceptibility to intraserial interference as was claimed by Malmo ('47). Similarly an analysis of the oscillations in correct response after the criterion of learning was met showed no changes which could be related to the effect of the operation.

SUMMARY. Although the memory and learning tests did not indicate any definite changes attributable to the operation in this study, it may be concluded that these tests and techniques reflect patient behavior in such a consistent manner that when modified they can be utilized to advantage in future studies. The Verbal Directions test for measuring immediate retention and the free and forced techniques in learning lists of nonsense syllables seem especially suggestive for further study.

Mental Set

INTERRUPTED SET. (Counting, reciting alphabet and months.) The number of errors in counting and in reciting the alphabet and months

Table 31

SPONTANEOUS SHIFTING OF SET (+) IN THE OPERATED AND CONTROL GROUPS FOR PREOPERATIVE AND POSTOPERATIVE TESTING

Operative Technique	N	Pre+ Post+	Pre- Post-	Pre- Post+	Pre+ Post-
VL	11	3	6	1	1
TO	5		3		2
TH	1		1		
TC	1		1		
All	18	3	11	1	3
Control	4	2	2	0	0

Eight patients out of 22, were able to change their set spontaneously before the operation. There were 6 operated and 2 controls in this group. After the operation 3 of the 6 operated patients could take the left route only when forced, although they were able to change their set before the operation; 3 remained unchanged. The 2 control patients also remained unchanged.

In order to get an estimate of the rigidity or flexibility exhibited by the patients, a clinical estimate was made of the quality of their total performance, including the spontaneous shift as well as the forced shift. The judgments were made with regard to changes from pre- to postoperative behavior in 3 steps; (1) increased rigidity, (2) increased flexibility, and (3) unchanged.

Table 32 shows the patient who evidenced a greater rigidity, a greater flexibility, or *remained unchanged postoperatively* by type of operation. Of the patients who showed greater rigidity postoperatively, 2 were venous ligations, 2 were transorbital lobotomies, one was a thermocoagulation, and one a thalamotomy. It is interesting to note, however, that all of the controls remained unchanged. It follows that any changes in performance cannot be attributed to the nature of the operation.

In order to obtain an overall quantitative measure of the performance of each patient, a total score was obtained in which each spontaneous change of set was given a credit of 2, and each error in the group of forced-change mazes was given a weight of -1. These scores for each individual were computed and the 66 scores obtained on the 3 tests were transmuted into a T-scale (Garrett, '47). The

INTERRUPTED TASK. There were 24 patients to whom this task was administered preoperatively. The tasks selected for this experiment did not hold equal interest for all patients. Some thought the jigsaw puzzle childish and refused to continue, while others thought it fun. It was felt that in some cases the non-resumption of the task after the interruption was a function of lack of interest, rather than lack of tension toward completion of the interrupted task. The selection of materials for this type of task for use with mental patients is a source of difficulty that we have not been able to overcome. It is for this reason that no postoperative data were obtained. If adequate testing materials can be devised this area of study might be of interest in a future study.

DIRECTIONAL SET. Data were obtained for this test on 22 patients, 18 operated and 4 controls. All but 2 of these patients were tested 3 times—twice preoperatively (-60A, -30B) and once postoperatively (+90C).

This test was aimed primarily at determining whether the right-turning habit established in the first 5 mazes induced a rigidity of performance that prevented spontaneous shifting to the shorter left-turning route. For those who did not make a spontaneous shift, a further opportunity for breaking the right turning habit was provided by the last 4 mazes in which the patient was forced to shift to the left. The number of errors which he made before turning leftward was a further measure of the degree of rigidity.

One of the most striking findings is the consistency of performance found in the 2 preoperative administrations. The patients usually repeated the same pattern of behavior on the second preoperative testing. Instead of the usual practice effects there was a preoperative rigidity. Of the 22 patients 14 could only take the shorter route when forced to do so on the last 4 street maps. These patients behaved as if they were suffering from psychic blindness extending over the left field of vision. After having established a right-turning habit, the shorter left route, seemed completely out of the realm of their perception. After the operation, 3 of these patients showed even a greater inability to relinquish the right-turning habit. One patient improved, being able to break the set spontaneously although unable to do so before the operation; the remaining 8 patients performed exactly as they had done before the operation. Of the latter 8 patients, 2 were controls.

Table 31 shows the pre- and postoperative performance of the operated and control groups with regard to spontaneous shifting. If a patient was able to shift spontaneously either at -60A or -30B he was considered as having shifted spontaneously preoperatively. In the group as a whole, 18 of the 22 patients did not alter their performance postoperatively, 13 remaining incapable of making the shift and 5 performing the shift spontaneously both times. Four patients altered their performance, one for the better and 3 for the worse. The control groups showed no changes from pre- to postoperative testing.

testing to the +90C testing 1.72 points. Although this difference was not found to be statistically significant, it nevertheless may be an indication of the general tendency for the operated patients to gain less than the control patients from repeated practice on a test.

A factor that cannot be overlooked, is an inadequacy of procedure which made it difficult to determine the basis of the postoperative changes. Five of the mazes were so constructed that the only correct solution was a right-turning movement, while on 4 others the patient had the choice of the previously established right-turning movement, or a "shorter" left-turning movement. These were given to see if the patient could shift "spontaneously." In the last 4 mazes the right-turning movement was blocked and the patient was forced to move to the left. Because the patients were not "forced" to take the left route in the second part of the experiment, some shifted and some did not. This freedom of choice might serve as a differential reinforcing agent upon the first and the third parts of the subsequent postoperative testing. There was nothing in the directions or the nature of the experiment to insure equality of reinforcement, nor was there any indication that the left route was possible during the second part of the experiment. Greater rigidity in the postoperative performance might be due to the fact that the right-turning tendency had more positive reinforcement through the patient's own choice. In view of this difficulty, the same mazes should not be reused postoperatively and a new type of maze should be utilized for testing for possible changes. Instead of a left-right choice, a top-bottom choice could be used in the postoperative testing. If one maze be inserted between the first and the second part of the experiment, for the purpose of demonstrating to the patient that a movement to the left is possible or calling attention to left-turning movements, it would eliminate the possibility of a "spontaneous" shift on the part of the patient, but it would make the data more amenable to analysis since it would equate reinforcement for all patients.

WORD SELECTION SET. The responses in the word selection tasks were scored by means of a T-scale technique (Garrett, '47). This numerical evaluation was obtained by tabulating the total number of correct responses at each exposure-trial per list, and then computing the corresponding T-scale score for each of the successive trials. This scoring method showed that the tests were too easy for the better patients, who had little difficulty in recognizing most of the words with a 10-millisecond exposure. Thus, an artificial ceiling was imposed upon the scores in that there was relatively little possibility of registering any significant improvements which might have occurred in postoperative performance. The data, though unsatisfactory, indicated a tendency towards postoperative improvement for the transorbital and venous ligation groups, but since the controls also show a slight gain in the second testing, a portion of this gain must be attributed to practice effects.

In general, these word selection tests appeared to be useful

Table 32

INCREASE IN RIGIDITY AND FLEXIBILITY OF SET IN THE POSTOPERATIVE TESTING

Operative Technique	N	Increase in Rigidity	Increase in Flexibility	Unchanged
VL	11	2	2	7
TO	5	2	1	2
TH	1	1		
TC	1	1		
All	18	6	3	9
Control	4			4

performance of each patient was then given its equivalent T-score and the means for the operative and control groups computed as shown in Table 33.

Table 33

MEANS OF OPERATED AND CONTROL GROUPS ON DIRECTIONAL SET TEST IN T-SCORES

Operative Technique	N	-60A	-30B	+90C
VL	11	51.36	50.82	50.45
TO	5	53.00	46.00	45.20
All*	18	51.00	49.44	47.72
Control	4	52.25	52.75	53.75

*Includes one TH and one TC patient.

It will be noted that the control group increased but slightly from test to test. The operated group as a whole declined from the -30B

Perceptual Tasks

DIGIT PERCEPTUAL SPAN. The evaluation of performance in this test was made in terms of the maximum number of digits correctly reported at an exposure of 10 milliseconds within 3 successive trials. Comparison of the mean changes in the operative and control groups showed that the operation produced no alteration in this function.

WORD RECOGNITION. Performance on Word Lists A and B was scored similarly to that in the word selection test making use of T-scale values. None of the statistical comparisons of the data obtained from the various subgroups were significant although there was some indication of improved performance in word recognition for the group of transorbital patients. The magnitude of this change was not large. That no type of psychosurgery used in this study improved perceptual span per se was indicated by the absence of any change in the perceptual span for digits.

SUMMARY AND CONCLUSIONS

In the study of the effects of psychosurgery on complex mental functions a battery of 14 tasks was used to measure memory, learning, maintenance of mental set, and perception. Since many of the scales involved were in a preliminary stage of development, an important aspect of the investigation consisted of sifting out the most suitable techniques for further research.

Among the tests which proved adequately reliable and sensitive were: (a) verbal directions, which measures the ability to grasp simple verbal directions; (b) the learning task, utilizing the names of pseudo radio stations; (c) the tachistoscopic tests of digit perceptual span and word recognition; (d) the word selection test, which is a measure of the ability to maintain a mental set; and (e) the sustained task, which requires continuous work at simple addition problems for a 15-minute period.

In general, the data obtained were not sufficient to warrant definite conclusions regarding the effects of psychosurgery on complex mental functions, but some interesting trends were noted. The operated patients tended to perform relatively poorly in the learning task when they were required to set their own tempo, although they showed a slight improvement over their preoperative performance when they learned under fixed speed conditions. In 6 of the 14 tests in the total battery the operated group did not show as much gain with test repetition as the control group.

It is concluded that:

1. Memory, both immediate and incidental, showed no alteration as a result of psychosurgery.

instruments for evaluating abilities in set and perception which might afford stable measures under more carefully controlled conditions than we were able to employ.

SUSTAINED TASK. The sustained task was given to 16 patients, 12 operated and 4 controls. The work curves for the operated and the control groups were plotted for the 15-minute work period minute-by-minute. The control group as well as the operated showed considerable variation from minute to minute and no trend was evident. There was a tendency in the control group for a steady rise in output per minute and no indication of any slowing within the 15-minute interval. This held true of both the preoperative and the postoperative test, but the latter in general was on a lower level of efficiency than the preoperative test. The operated group showed a short warming-up spurt followed by a gradual decline. This held true of the preoperative as well as the postoperative test.

In the absence of any significant differences between the operated and unoperated groups, the performances of the individual operated patients were examined for any consistent trends which might be related to the surgical technique employed. No relationship was found.

The findings of Conkey ('38) and M. F. Robinson ('46) suggested that we might find a change in the ability to sustain performance from the beginning to the end of the task as a result of psychosurgery. However, a comparison of the slopes of the curves of performance from the first to the fifteenth minute for the pre- and postoperative test periods showed some changes in a positive direction and some in a negative direction, which failed to support the Conkey-Robinson hypothesis.

The possibility that the accuracy of performance might change as a result of operation was examined by making a graphical comparison of the preoperative and postoperative error scores. No significant trends were found. The analysis of the data and graphs of the 2-digit additions revealed no consistent tendencies when examined in terms of total number of additions completed, the range of each patient's preoperative and postoperative performance, shape of the curve of performance, and the error scores.

It is to be noted that in the above discussion the analyses have been primarily based on an inspection of the graphical material. In view of the irregularity of the data, refined statistical treatment did not seem warranted. So far as the sustained task method is concerned we may summarize by pointing out that no significant changes which could be ascribed to the operative procedures were found with respect to; (a) total number completed, (b) range of performance, (c) shape of the curve of performance, and (d) total error scores. This was true in both the one- and 2-digit addition tasks.

there was no sound evidence that the variety of neurologic surgery conducted on the frontal lobes of these 22 patients had any important differential effect on the psychologic variables measured.

2. Learning ability showed no definite alteration directly attributable to psychosurgery. "Forced" tempo learning seemed somewhat easier postoperatively for most of the operated cases and "free" tempo learning seemed somewhat more difficult for them.

3. In the control group, but not in operated patients, there was evidence of improvement of maintenance of set which we attribute to the practice effect of the repeated testing procedure.

4. Although our technique was not all that might be desired, we must conclude that the delayed reaction phenomena reported in brain-operated animals was not evident following psychosurgery in this group of patients.

5. The verbal directions test here, as in the first Columbia-Greystone project, showed some tendency to change in an unspecific fashion following psychosurgery.

6. Neither interrupted set nor the interrupted task test showed a consistent variation following psychosurgery.

7. The test of directional set, which had been specially designed to bring evidence as to changes in rigidity or flexibility in learning or in mental set, failed to show any consistent change which could be related to psychosurgery. This might be due to inadequacy of materials and method used, although the results were in agreement with the clinical evaluation of the patients.

8. Stimulus word recognition, which was used as a substitute for the word association test, gave an improvement in scores with the transorbital group which paralleled the improvement shown by the control group. This difference between the transorbital group and the other operated patients is not due to differences in visual perception span.

9. The Conkey-Robinson hypothesis that psychosurgery or brain injury results in a loss in ability to continue a sustained mental task without marked decrease in efficiency was not confirmed.

10. Several general tendencies appeared. For example, no striking changes for the worse were noted. Such changes for the worse as did occur reflected not a basic loss, but rather a failure to show improvement with practice. There were 14 opportunities for comparing the effect of practice on the performances of the operated and the unoperated patients. In only 3 of these did the practice benefit the operated more than the unoperated. In 6 of these comparisons the operated trailed behind the unoperated and in the remaining 5 instances no marked differences appeared.

11. During the period covered by these psychologic examinations little or no amelioration in mental illness was evident. The psychologic findings in the first Columbia-Greystone report all pointed to the fact that such alterations (gains or losses) in psychologic test performance as were found were more closely related to "social improvement" than to any other variable investigated. Hence, the lack of regular change in this battery of tests is in all probability a reflection of the lack in amelioration from mental illness. Certainly and positively

By use of the coding system and a large number of questions a considerable amount of material could be obtained from each patient and recorded in an objective manner so that it lent itself to both group and individual analysis. This procedure provides a method of discovering the effects of brain operations on material which is essentially subjective. Through the large range of questions there is an adequate opportunity for the patient to express his particular troubles. Through the recording technique, what the patient says and how he says it, are available for analysis.

As one's experience grows, alterations are usually required in any new technique. This does not make for experimental neatness and clear-cut results. As a result of such necessary alterations much of the data obtained during the course of this study are fragmentary and for that reason, if no other, the results presented in this paper are tentative.

METHOD

The present investigators made use of a common method but each sought information on a different set of topics. Interview A which consisted of 180 questions arranged in blocks according to their content dealt with general topics of (a) insight, (b) feelings of persecution, (c) religion, (d) feelings of guilt and punishment, (e) prejudice (religion, racial, national), and (f) hallucinations. Interview B consisted of 160 questions which were primarily concerned with the way in which the patient had reacted to various events in his development from childhood until the present. Postoperatively, additional questions were added to both interviews concerning special effects connected with the operation and its effects.

The responses to both interviews were recorded at the time of the interview through the use of symbols and abbreviations. Explanatory notes or elaborations deemed necessary were noted. Because primary emphasis was placed on the development of a code for recording the actual responses to the interview questions, the development of symbols denoting characteristics of the patient's way of speaking was delayed. Only 2 of these, indicating bizarreness and indirect or interpreted answers, were used sufficiently to warrant reporting in this study.

In the absence of any other criterion, the scoring of the interview content was based on what were considered the expected "normal" answers to the questions. Only those questions to which the normal answers were judged by the experimenters to be clear were included in this scoring. Four content scores based on this expected normal record are reported in this study. These scores are based on the blocks of questions from Interview A concerning: (1) insight, (2) persecution, (3) prejudice, and (4) guilt, and they consist of the total number of good or normal responses present in each patient's record.

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Chapter 11

ATTITUDE EVALUATION

Mortimer Garrison, Jr., and Tom D. Olin

Psychosurgery done with the hope of producing an amelioration from psychosis and neurosis has been reported by various investigators to produce changes, both desirable and undesirable, in the attitudes of the patient toward life and life's problems. Cases described as having changed with respect to politics and religion have been cited and discussed by Reitman ('48), Hutton ('47), and Rylander ('49).

These reports are usually based on clinical observation frequently documented by protocols and accounts of improved patient's behavior after their return to their families. In effort to specify certain of these changes more objectively, psychologic inventories of common complaints and fears were reported by Garrison ('49). These inventories were not too satisfactory since the possible range of complaints, presented to the patient, was restricted and the range of answers was determined by a card containing certain standard answers from which the patient was asked to choose the answer which most corresponded to the way he felt.

As a consequence of the positive results obtained with the Anxiety and Complaint inventories the present study was undertaken as an exploratory effort to develop a method which would provide a more precise self-description of the mental patient. It was decided to base this work on the direct interview. This decision was prompted by the success attained by Kinsey ('48) and his associates, particularly with respect to their ingenuity in coding their subject's responses so that a great many questions might be asked, answered, and accurately recorded in a relatively short time.

Two problems predominated in our development of this method: (a) determining the content of the interview question, and (b) devising a code for recording the answers. The interview content was at first based on the Anxiety and Complaint inventories and on the sorts of questions commonly used in psychiatric interviewing and "trouble" questionnaires. The succession and wording of the questions were continually changed so that any particular interview moved naturally from one topic to another. As our familiarity with the method increased it became evident that more of the patient's behavior might be indicated in the record forms than simply the answers to the questions. This observation led to the beginning of the development of a system of symbols representing the characteristics of the patient's speech.

procedure was used with Interview B in order to see whether old impressions and attitudes toward past events could be considered reliable or whether a therapeutically successful operation might not consistently change the patient's way of evaluating his past life.

Table 34

THE AGE, SEX, IQ, DIAGNOSIS AND OPERATION FOR THOSE PARTICULAR SUBJECTS INCLUDED IN THE ATTITUDE EVALUATION. SEE ALSO FIGURE 6 AND TABLE 5

Operative Technique	Patient	Age	Sex	IQ	Diagnosis
VL-I	B1	33	F	90	Hebephrenic schizophrenic
VL-I	B2	33	F	102	Catatonic schizophrenic
VL-I	B3	34	F	89	Hebephrenic schizophrenic
VL-I	B5	51	F	97	Paranoid schizophrenic
VL-II	B6	32	M	100	Catatonic schizophrenic
VL-II	B7	35	F	85	Hebephrenic schizophrenic
VL-II	B8	47	F	102	Paranoid schizophrenic
VL-II	B10A	52	F	114	Paranoid schizophrenic
VL-II	B11	32	F	88	Catatonic schizophrenic
VL-II	B12	26	F	93	Catatonic schizophrenic
TH	B14	26	M	58	Hebephrenic schizophrenic
TO	B17	33	F	56	Hebephrenic schizophrenic
TO	B19	34	M	55	Hebephrenic schizophrenic
TO	B20	27	M	74	Hebephrenic schizophrenic
TO	B28	30	M	90	Incipient schizophrenic
Control	B10	42	F	86	Paranoid schizophrenic
Control	B22	36	F	103	Hebephrenic schizophrenic
Control	B24	44	F	100	Paranoid schizophrenic
Control	B25	32	M	115	Catatonic schizophrenic
Control	B27	28	M	115	Hebephrenic schizophrenic

		Mean Age	Mean IQ
Operated group	N=16*	34.7*	85.6*
Control	N=5	36.4	103.8
Venous ligation	N=10	37.5	96.0
Other operatees	N=6	30.0	68.3

*Including patient B4

The information obtained concerning hallucinations was not included in this treatment since too few patients answered these questions relevantly.

Four additional scores have been used which depend upon the incidence of certain phenomena in the patient's interview records. These Incidence scores were as follows: (1) Bizarre responses. This score consisted of the incidence of irrelevant, hallucinatory responses in which no scorable content response was evident. A special symbol was used to indicate this sort of behavior. (2) Interpreted responses. These were indirect responses in which the patient's answer was evident but not directly given. A special symbol was used in recording this type of response. (3) Don't know responses. This score would probably better have been named "Unable responses" since it included "Don't know," "Don't remember," and "Can't say." Since the majority of the questions concerned attitudes it seemed likely that a high incidence of this sort of response might be significant. These responses were represented directly in the records as they were given by the patient. (4) Uncertain responses. No special symbol was used to indicate the presence of this type of response but it was evident in the records through symbols which were contradictory or by the patient's remarks qualifying his response. This score represents multiple contradictory answers to the same question and cases in which the patient's elaborations contradicted his response to the question. It does not overlap the other Incidence scores even though no special symbol was used.

These 4 scores depend in part upon the total number of questions answered by each patient. As a result, the direct incidence of each phenomenon was expressed as a percentage of the number of questions asked per patient and these percentages were treated as scores. The Content scores varied only slightly in this respect and therefore were not expressed as percentages.

EXPERIMENTAL DESIGN

Because of changes in both the content of the interview and the recording technique, the first preoperative interview of Interview A could not be directly used as it was too dissimilar to the later data for close comparison. Hence the results of preoperative Interview A obtained the month immediately preceding operation and 2 postoperative A interviews giyen 10 days and 3 months respectively following the operation were the only "standard" material available for analysis.

Interview B contained so much material relating to the patient's past history that it was split preoperatively, the questions covering the period before hospitalization being given 2 months prior to operation; the questions concerning hospitalization and present status being given during the month immediately preceding the operation. The whole interview was repeated 3 months following operation. This

Table 36

INTERVIEW A: THE MEANS AND STANDARD DEVIATIONS OF THE INCIDENCE SCORES FOR THE VARIOUS GROUPS AT 3 INTERVIEW PERIODS

Operative Technique	N	-30A M	-30A SD	+10B M	+10B SD	+90C M	+90C SD
Interpreted							
VL	10	2.1	1.8	3.8	3.3	14.9	12.3
TH & TO	5	3.5	2.0	8.4	13.8	10.7	11.7
Control	5	8.3	3.9	21.5	3.5	35.5	19.4
Don't Know							
VL	10	6.9	7.8	6.7	7.7	5.5	6.1
TH & TO	5	11.6	9.6	13.5	14.6	14.1	13.2
Control	5	3.9	2.5	4.5	2.2	2.9	2.0
Bizarreness							
VL	10	2.6	5.2	1.2	1.4	2.7	6.8
TH & TO	5	4.1	4.5	2.7	5.1	2.7	6.0
Control	5	3.8	5.7	2.2	4.4	2.0	2.5
Uncertainty							
VL	10	6.7	5.2	6.8	5.2	6.2	3.8
TH & TO	5	5.3	3.4	5.8	4.4	8.2	3.3
Control	5	4.4	4.4	10.2	8.4	7.6	2.9

number of operated cases to 15. This operated group consisted of 10 venous ligations, one thalamotomy, and 4 transorbital lobotomies. The venous ligation group and the control group were comparable with respect to age and IQ but the other operated cases formed a group with a lower mean IQ and a somewhat lower mean age. None of these groups provided an adequate population for statistical treatment but this difference within the operated group made it necessary to examine the data for the 2 operated subgroups separately.

SUBJECTS

The subjects included in this study are shown in Table 34 together with the relevant background information. Usable and representative preoperative data were obtained on 16 operated cases and 5 controls. Case B4 (a venous ligation) died shortly after operation, reducing the

Table 35

INTERVIEW A: THE MEANS AND STANDARD DEVIATIONS OF THE CONTENT SCORES FOR THE VARIOUS GROUPS AT 3 INTERVIEW PERIODS

Operative Technique	N	-30A M	SD	+10B M	SD	+90C M	SD
Insight							
VL	10	16.5	4.3	17.2	4.2	18.7	4.4
TH & TO	5	13.7	4.6	15.7	3.2	15.0	4.4
Control	5	18.0	1.7	18.8	5.4	18.8	5.5
Persecution							
VL	10	19.6	6.5	22.0	5.4	21.8	6.6
TH & TO	5	24.8	6.4	26.0	3.9	27.3	4.2
Control	5	20.0	6.2	20.8	4.4	21.0	6.4
Prejudice							
VL	10	39.2	11.3	40.7	9.7	41.4	10.8
TH & TO	5	40.0	10.6	38.8	8.4	42.5	7.2
Control	5	30.6	9.1	33.6	12.7	34.4	12.0
Guilt							
VL	10	9.4	3.1	9.7	2.9	9.2	3.4
TH & TO	5	8.5	3.2	9.3	1.8	9.7	3.6
Control	5	6.4	2.2	8.4	3.2	7.2	2.2

remained unchanged while the other operated cases increased postoperatively.

PATTERN ANALYSIS. Another method of surveying the data for the effects of operation is through pattern analysis. Each patient was interviewed 3 times and a change might occur each time or in any other possible pattern when all 3 answers to each question are considered. Were it found that there were differences in the way in which these changes took place between the groups as indicated by the relative predominance of the various patterns, this change might be attributed to the operations.

The incidence scores were tabulated in each pattern and the incidence for each pattern was expressed as a percentage of the number of questions asked per patient. These percentages were then averaged to indicate the relative predominance of each pattern in the various groups. These figures are shown in Table 37.

In the heading of this table and in the text to follow 3 letters have been used to represent the pattern taken by the answers. An "x" indicates the presence of the behavior under consideration; an "o," its absence. Thus xox—present preoperatively, absent at the first postoperative interview, and present 3 months postoperatively.

There was some difference between the groups in the numerical value of these figures depending upon how much of the behavior determining these percentages was present. There was some indication from this analysis of a difference between the 2 groups of operated patients; since the bizarre and "Don't know" responses were less frequently found in the xxx pattern indicating presence of these responses throughout the 3 interviews in the venous ligation group than was the case in the other operatees. The venous ligation group differed from both the control group and the other operatees in that there was a greater frequency of "Don't know" responses in the xox pattern and a lesser frequency of this type of response in the oxo pattern. The venous ligation group also had a lower frequency of bizarreness occurring in the oxx than did the controls. In this pattern the other operatees exceeded the controls.

This indicates that the venous ligation group gave a greater proportion of direct answers immediately following operation with the "Don't know" responses returning 3 months postoperatively. The other operatees on the other hand gave more new bizarre responses following the operations than did either the venous ligations or the controls. Despite this difference between the groups, there was no evidence of any difference in these patterns of change between the operated group as a whole and the control group.

DIFFERENCE SCORES. The possibility remains that significant changes may have occurred in individuals despite the lack of difference between the group means. The scores used in examining this possibility were the algebraic differences for each score between conditions

RESULTS: INTERVIEW A

CONTENT SCORES. The means and standard deviations of the Content scores for the control group, and the 2 operated subgroups are given in Table 35. There are no significant differences either between the groups or from pre- to postoperative conditions evident in this table. Both the operated and control groups increased in the number of "normal" responses to questions dealing with insight and persecution. In both cases the operated group increased slightly more than did the controls. Both groups increased somewhat in the number of normal responses to questions concerning prejudice and guilt although in these scores the control group increased somewhat more than did the operated group.

Despite the difference in background variables between the 2 operated subgroups there were no differences between them with respect to these scores.

INCIDENCE SCORES. The means and standard deviations for the various groups with respect to the Incidence scores are shown in Table 36. Although there are some differences between the groups preoperatively, there are no differences attributable to the effect of operation evident in this table. The operated and control groups were significantly different preoperatively in the incidence of interpreted responses, the control group giving more of this type of response. The large increase in the control mean immediately following the operations enlarged this difference but there was also a small increase in operated mean as well. The groups did not differ significantly at the second postoperative interview, despite the large difference between the means, because of the scatter indicated by the standard deviation in the control group.

The 2 groups differed significantly before operation in the use of the "Don't know" type of response, the operated group exceeding the controls. The other operatees increased during both postoperative interviews accounting for the rise in the operated group mean for this score. Although both the venous ligation and the control groups decreased slightly, the mean differences between the groups are not significant postoperatively and the changes between pre- and postoperative conditions are not significant.

The groups did not differ significantly at any time in the incidence of bizarreness and uncertain responses. Both groups decreased postoperatively in the bizarreness score. The operated group decreased somewhat more than the controls immediately following operation but increased 3 months later although not to the extent that there was a return to their preoperative level. The venous ligation group was less bizarre than the other operatees preoperatively but was equivalent to them postoperatively. With respect to uncertain responses, the operated group as a whole remained unchanged while the control group increased in the incidence of this response. The venous ligation group

for each patient. The net difference represents the total change for the score under consideration from the preoperative interview to that done 3 months postoperatively.

To investigate and evaluate the changes which actually did occur in each patient's record it was necessary to know something of the relationships between the separate scores. In order to determine these relationships, an intercorrelation of the net differences for each score was done. Related scores were expected to change similarly in each patient. These correlations are shown in Table 38. Although the

Table 38

INTERVIEW A: RANK-ORDER CORRELATIONS BETWEEN THE NET DIFFERENCES IN SCORE FROM THE PREOPERATIVE TO THE 3 MONTHS POSTOPERATIVE INTERVIEW. (N-21)

	Interpreted	Don't Know	Bizarreness	Uncertain	Insight	Persecution	Prejudice	Sin
Interpreted		-.01	+.02	+.94	-.26	-.26	-.14	-.38
Don't Know			+.05	-.39	-.34	-.06	-.08	+.06
Bizarreness				+.17	-.27	-.12	-.68	-.43
Uncertain					-.14	-.60	-.21	+.26
Insight						+.48	+.28	+.33
Persecution							+.24	+.29
Prejudice								+.40
Sin								

correlations in this table are not high, there is a consistency which supports the hypothesis that the Incidence and Content scores vary inversely: an increase in the Content scores would be expected to accompany more direct answers or a decrease in Incidence scores. This seems reasonable to expect particularly in the case of the bizarreness score. The possibility still exists that these scores may increase together; that flashes of insight might occur in a patient whose verbal behavior had generally deteriorated, but any patient in whom a

Table 37

INTERVIEW A: PATTERN ANALYSIS OF INCIDENCE SCORES SHOWING THE RELATIVE IMPORTANCE OF THE PATTERNS OF CHANGE IN THE VARIOUS GROUPS*

Operative Technique	N	xxx	xoo	xxo	xox	oxo	oox	oxx
Interpretive								
VL	10	1.3	1.0	.4	.6	2.3	13.1	1.0
TH & TO	5	.7	1.7	.3	.8	5.0	5.0	2.5
Control	5	1.8	3.2	1.3	2.3	9.8	22.5	8.8
Bizarreness								
VL	10	.3	2.7	1.5	.7	4.7	8.7	1.8
TH & TO	5	4.7	3.8	1.5	2.2	7.8	6.0	11.5
Control	5	5.4	2.6	3.0	1.2	12.6	10.8	10.6
DK's								
VL	10	1.7	3.3	1.3	3.1	2.2	1.0	1.8
TH & TO	5	5.0	4.7	2.2	2.3	4.0	4.5	4.0
Control	5	1.0	2.2	.6	.4	1.8	.8	.8
Uncertainty								
VL	10	.2	7.4	1.1	.7	5.0	4.7	.5
TH & TO	5	.2	3.8	.5	.7	4.5	6.5	.8
Control	5	0	3.4	1.2	0	8.6	7.0	.4
Complete Means								
VL	10	.6	3.6	1.1	1.3	2.8	6.9	1.3
TH & TO	5	2.6	3.5	1.1	1.5	5.3	5.5	4.7
Control	5	2.0	2.3	1.5	1.0	8.2	10.3	5.1

*X=presence of the phenomena
O=absence of the phenomena

Without significant changes in the group data, it is doubtful whether any individual changes may be attributed to the operation unless they markedly exceed both the other operated cases and the control group in magnitude. The greatest change in the control group was a -59; none of the 5 control patients changed in a positive direction. Two of the operated cases (B3, B20) had similar negative scores. In any appraisal of these cases the initial level of their performance must be taken into account. In these data this level depends on the preoperative presence of Incidence scores and normal Content responses. An overall figure combining the differences found in these 2 types of scores would be fruitless since an individual who was functioning at an originally high level would be unable to change positively in Incidence scores. Both B3 and B20 had scores preoperatively which were the equivalent of the control patient whose score decreased the most. There was adequate opportunity for both the 2 operated cases and the control to improve their scores but all 3 decreased and hence there seems no reason to attribute this decrease in the operated cases to the operation.

B10A and B12 stood out among the operated cases whose changes were positive. B10A improved immediately following operation on 5 of the 8 scores; one being unchanged, 2 Incidence scores increasing slightly. The most notable change in this case occurred in the Content scores. This patient's major complaints revolved about auditory hallucinations which she claimed were reduced following the operation. Three months postoperatively there was only one additional change, an increase in the number of interpreted responses. B12 immediately following operation improved on 5 of the 8 scores; one remaining unchanged, decreases taking place in 2 of the Content scores. The gain in this case was primarily in a decrease in the number of "Uncertain" and "Don't know" responses with little change occurring in the Content scores. Three months later these scores were reversed with the Incidence scores returning to the preoperative level and a slight increase being present in the persecution and prejudice Content scores.

In the cases of B10A and B12 their preoperative level was of some importance. B12 exceeded B10A in the frequency of "Don't know" and uncertain responses preoperatively. B10A consistently exceeded B12 in good Content responses and thus appeared better than B12 before operation. B10A had little opportunity to decrease in Incidence scores and thus could not have built up much of a positive difference based on these scores. Nevertheless the changes in this patient's record outweighed those in B12 because B12's changes were mainly confined to the Incidence scores while B10A changed in both Incidence and Content.

SUMMARY: INTERVIEW A

1. There were no significant differences found in either the Content or Incidence scores attributable to the effects of operation.

marked improvement had taken place would not be expected to behave in this manner. These relationships are far from perfect but as a working hypothesis the assumption will be made that an increase in Incidence scores is negative with respect to improvement in the patient while an increase in Content scores is positive.

By algebraically summing the differences of each patient's scores it is then possible to arrive at an evaluation of the changes which did take place in these records. Table 39 shows the number of patients in each group according to whether the changes which occurred were positive or negative.

Table 39

INTERVIEW A: THE DIRECTION OF CHANGE BY PATIENTS AT EACH POSTOPERATIVE INTERVIEW WITH THE NET CHANGE FROM THE PREOPERATIVE INTERVIEW

Operative Technique	N	+10B		+90C		Net change (-30A less +90C)	
		+	-	+	-	+	-
VL	10	7	3	4	6	5	5
TH & TO	5	3	3	2	4	3	3
Control	5	1	4	0	5	0	5

From this table it may be seen that the overall results 3 months following the operations were not impressive. It would appear that such positive changes as did take place were predominantly present immediately following operation and that there was a tendency for these changes to be lost 3 months later. It must be borne in mind that these changes in most cases represented a very small percentage of the total questions. It is notable that the 3 venous ligation cases whose change was in a negative direction immediately following operation had operations which might be considered more severe than were the others of that group.

The results from this tabulation are reflected in the pattern analysis in that the venous ligation group responded with "Don't know" relatively more frequently in the xox pattern indicating a greater directness of answers immediately following operation when according to Table 37 many of them had changed somewhat for the better. In the same fashion there is an indication that the other operated cases were more affected by operation in that they had a greater frequency of bizarreness in the oxx pattern indicating its appearance at the 2 postoperative interviews when according to Table 37 there were fewer positive changes in this group than took place in the venous ligation group.

him. This might alter following a mood change. Such material can only be evaluated with respect to accuracy and inaccuracy as determined by the case histories of the patients or by comparison to the records of a criterion group of improved patients. In the absence of such criteria an exhaustive group treatment of these data would be fruitless.

A tentative conclusion may be drawn concerning the reliability of attitudes toward past and present events despite operation or the passage of time. The mean changes occurring in these 2 types of material are shown in Table 40. There was little change in either the operated or control groups and there were no significant differences between the groups.

It was much more difficult to provide a hypothetically normal score for this interview than for Interview A because of the number of questions which were basically factual in content. Nevertheless such a scoring was done particularly for correlation with the results from Interview A. The number of questions varied from case to case so the "normal" score was expressed as a percentage of the total questions per patient. The mean normal score for the operated and control groups is shown in Table 41.

Table 41

INTERVIEW B: MEAN PER CENT "NORMAL" SCORE PRE- AND POSTOPERATIVELY FOR THE OPERATED AND CONTROL GROUPS

Group	N	-30A	+90B
Operated	16	71.8	69.7
Control	4	58.0	59.3

The operated and control groups differed on this score before and after operation but the score is quite stable when the pre- and postoperative conditions are considered. This lack of change in the groups compares with the more accurate data obtained with Interview A.

One score from both interviews which could be directly compared is the bizarre response incidence score. Due to differences in the application of this scoring preoperatively, the rank-order correlation between the scores from Interviews A and B was only +0.46. Three months following operation this correlation had risen to +0.87 indicating a refinement in the application of this score and considerable agreement between the 2 interviewers. There was substantial disagreement on only one patient in whose record more bizarreness was indicated at the time of Interviews B and A. This might be attributable to the score, the interviewers, or to changes in the patient.

2. The net difference scores representing a small percentage of the total questions were intercorrelated and it was found that the Content and Incidence scores tended to vary inversely supporting the hypothesis that improvement was indicated by an increase in Content scores accompanied by a decrease in Incidence score.

3. A tabulation according to the algebraic sum of the differences from the pre- to postoperative interviews with each patient indicated a trend towards improvement in some patients immediately following operation which was not sustained 3 months later.

4. A pattern analysis of the changes in the Incidence scores gave some indication that the venous ligation group and the other operatees differed. An evaluation of these differences made in light of the relationships between the scores suggested that the other operatees changed somewhat more in a negative direction than did the venous ligation group.

5. Among the individuals, B10A and B12 were regarded as somewhat improved while B3 and B20 appeared to be somewhat worse following operation. In none of these patients was the change striking enough to be considered more than that attributable to the variability frequently seen in hospitalized mental patients when interviewed from time to time.

RESULTS: INTERVIEW B

The first 80 questions in this interview dealt with the prehospital experience of the patients. It was expected that substantial change in any group of patients would be reflected in these questions through the psychosis-free re-evaluation of the experiences involved. For example: it had been observed that an individual in a depressed state might describe himself as having been worthless all of his life even though he might have had a considerable period of achievement behind

Table 40

INTERVIEW B: THE MEAN CHANGES OCCURRING IN THE QUESTIONS CONCERNING ATTITUDES TOWARDS PAST AND PRESENT EVENTS FOR THE OPERATED AND CONTROL GROUPS

Group	N	Questions concerning the past	Questions concerning the present
Operated	16	9.1	8.1
Control	4	8.8	7.5

her comments that she was a little more troubled by her hallucinations but this was not marked enough to affect her score nor were her complaints quantitatively similar to those she had expressed preoperatively. These changes in this patient seemed to be of particular importance because of the emphasis she placed on these phenomena preoperatively.

QUESTIONS CONCERNING THE EFFECTS OF OPERATION. During the postoperative interviews all patients were asked 50 questions concerning their awareness of their operation and its effects upon them. A number of the patients denied having had an operation at one or more of the postoperative interviews. These data have been tabulated according to whether the patient's answers indicated whether he felt that the changes in him were primarily good or bad. This tabulation is shown in Table 42.

Table 42

OPINION OF 16 OF THE OPERATED PATIENTS CONCERNING THE EFFECT OF THE OPERATION AT 15, 60, AND 90 DAYS AFTER OPERATION

Effect	+15B	+ 60C	+ 90D
Good	9	7	5
Bad	3	2	2
Equal	1	1	0
None	0	2	4
Operation Denied	3	4	5

It is interesting to compare these results with those shown in Table 39 reporting the results in terms of the difference scores. Those patients who denied having an operation complicate any comparison between these 2 tables, but the impression remains that the patients' reports of what effects the operations had on them and the results shown by the Content and Incidence scores are in accord.

AMNESIA. Three months after operation an attempt was made in connection with Interview B to ascertain whether retroactive amnesia was present in any of the operated patients, through the use of questions designed to elicit information without actual prompting. Two of the venous ligation, both thalamotomy, and 3 transorbital lobotomy patients denied events which had taken place during the month immediately preceding the operations. Of these 3 patients may be ruled out

To obtain an indication of how much agreement was present between the 2 interviews in their overall appraisal of changes in these patients a rank-order correlation was done between the total net difference scores from both interviews. This correlation was +0.58 being reduced by substantial disagreement in the interview reports of patients B1, B5, B12, and B17. There was complete agreement in 8 of the patients which was satisfying in view of the differences between the interviews and their susceptibility to day by day variation on the part of the patients.

SUMMARY: INTERVIEW B

1. There were no significant differences in the groups "normal" scores before and after operations.

2. No differences were found between the groups before or after operation with respect to changes occurring in questions dealing with past and present events.

3. Correlations between the 2 interviews showed that at the time when they were most comparable (3 months postoperatively) there was a substantial agreement between the bizarre response Incidence score but a less satisfying correlation was found between the total net difference scores.

SPECIAL CONSIDERATIONS

QUESTIONS CONCERNING HALLUCINATIONS. Complete results from the section of questions in Interview A concerning hallucinations were obtained on 4 operated patients and 3 controls. Of the 4 operated cases, 2 improved somewhat so far as hallucinatory experience was concerned following operation, while the condition of the other 2 was unchanged. All 3 of the controls seemed to be somewhat more hallucinated 3 months after the operative period. The most notable change occurred in B10A. Immediately following operation this patient reported that the voice which she usually heard "Was better and that he had not been changing her face." Most of her preoperative complaints had been attributed to the effects of things happening to, or being done by the individual whose voice she heard. That the voice did not vanish entirely was indicated by her comment that "He seems better: he is more considerate." Despite her conviction that this was a real instance of mental telepathy or something similar, her social alertness before and after operation was indicated by the comments she made stating that she would never have told the interviewer about her hallucinations had he not been a doctor; further, that no one would know that she was hallucinated if she did not mention it. At the time of the second postoperative interview (+90C) there was some indication from

Janis ('48) using intensive interviews reported the presence of retroactive amnesias in 19 mental patients following electrical convulsive therapy (ECT). He suggested that there might be a causal connection between the amnesias following ECT and the affective changes produced by the treatments. Since the majority of his interview questions concerned subject matter which had a high emotional value for the patients he studied, the lack of change in our data is not in line with his finding but since our study was exploratory, it is likely that Janis' hypothesis has not been adequately tested.

SUMMARY

Two interviews were used to obtain self descriptions from 21 mental patients before and after operation with respect to their attitudes toward their problems, religion, sex, prejudice, feelings of guilt and persecution, and their life histories. Of these 21 subjects, there were 10 who were subjected to venous ligations, one to thalamotomy, 4 to transorbital lobotomies, one to an extended topectomy while 5 remained as control patients. In general the interviews indicated that these patients tended to report consistently. The operations failed to bring about any overall change in attitude in this group. Two operated patients gave evidence of an amelioration of their hallucinatory experience, 2 other operated patients failed to experience such a change, and 4 control patients gave evidence that their hallucinations became more dominant in their mental life over a 3-month period. Some patients were of the opinion that the operation they received ameliorated their mental illness, others said it had no effect or made their condition worse, while a few denied that they had been subjected to neurosurgery. Three months after operation 6 patients gave evidence of retroactive amnesia extending for several weeks before their operation. None of the findings were related in a consistent way to the surgical technique employed.

APPENDIX

The following questions are sample lists of those employed in the attitude evaluation. There were 237 questions in Interview A and 155 in B.

From Interview A:

Insight:

8. Do you know why you were brought here?
9. Do you think people were trying to help you?
10. Where should you have gone?
11. Are there people now trying to keep you in here?

on the grounds of insufficient contact with reality (including the interviewer) during this period. B6 denied the whole experience claiming that his memory was good only for the 2 weeks preceding the interview. He cannot be excluded on the basis of poor contact since this was not indicated by his usual behavior. B12 denied having had any medical examinations preceding operation. B13, a thalamotomy excluded from other considerations in this report, remembered having been examined preoperatively but denied having an operation. He stated that he did not recall being prepared for operation nor had he any memory of wearing bandages. As far as he knew he, "Woke up with a short haircut."

SUMMARY: SPECIAL CONSIDERATIONS

1. Too little data were obtained to justify a full treatment of the hallucination content questions from Interview A. Of the 4 operated patients included in this section, 2 lost some part of their hallucinatory experience and 2 did not.

2. Additional questions asked concerning the effects of operation indicated that some patients were of the opinion that the operation had been beneficial, others that it had made their condition worse or no better, while some denied that any operation had taken place.

3. Questions designed to elicit evidence of retroactive amnesia. About half of the operatees gave evidence of more or less complete amnesia for the one to 2 weeks before their operation. The amnesia was not related to the surgical technique utilized.

DISCUSSION

The most striking point evident from this group of patients was the consistency of their reporting. None of the group means varied in a manner which would suggest that they were influenced by any variety of psychosurgery employed in this study. There were a sufficient number of patients on whom venous ligations had been performed so that the data for this conclusion are of some relevance in evaluating the effects of that operation. The previous venous ligation patient (No. 38) reported in the first Columbia-Greystone project (Garrison, '49) was improved following the operation with respect to her scores from the Anxiety and Complaint inventories. In this larger sampling of patients there was one (B10A) who made a fair social improvement but it is impossible to say whether or not these 2 cases are similar because of the differences in the techniques used in the social improvement evaluation. The change in this patient did not seem greater than could be expected from the effects of variability in mental patients and thus is not solely attributable to the operation.

Religion:

60. Do you usually go to church services when you can?
61. How often? (a) everytime (b) most of the time (c) once in a while (d) rarely (e) not at all (f) no chance.
62. Has religion helped you? (a) hindered (b) not thought of (c) prayer (d) thoughts (e) read (f) services (g) all.
63. Did you have religious training while growing up? (a) home (b) Sunday School (c) school (d) other.

Relations with Others:

71. Do you ever get angry when your religion is abused?
72. Do you hold grudges?
73. Have you had arguments with anybody on the ward?
74. Do you ever feel as though visitors stare at you?
75. Do you prefer to be left alone as a rule?

Mental State:

122. Do you have trouble finding the right word for what you want to say?
123. Do you have trouble understanding other people?
125. Do you have trouble with your hearing?
126. Are you afraid you might have?
127. Have you ever felt that thoughts were being put into your head?
128. How often do you hear people talking to you when you can't see them?

Racial Groups:

105. Would you mind if one of your friends married a Jew (Christian, as the case may be)?
106. Are they usually able to get more from the attendants than you?
107. Do you find them hard to get along with?
108. Have you noticed that they seem to be plotting against you?
117. Do you have any Negro (white, as the case may be) friends?
118. Do you mind associating with them?
119. Do you ever feel disgusted when you look at them?
137. Do you think some foreigners (or fascists) would like to get control of this country?
139. Do you think we ought to try to keep America for the Americans?

Voices:

147. Are you hearing voices now?
148. Do you hear them more when you are alone?
149. Are you able to stop them when you want to?
150. Are you bothered by them?

12. Would you like to leave this place?
13. Do you know any reason why you can't leave now?

Persecution:

46. Are people doing things that are wrong to you?
47. Do you frequently feel suspicious of people?
48. Are some people secretly stealing things from behind your back?
50. Do you think people are trying to deprive you of your rights?
51. Which people seem to be doing the most damage to your life?

Religion:

67. Which religion do you dislike?
68. Do you think a person's religion is an important thing?
69. Have you ever known people who don't believe in God?
70. Are these people worse in some ways than those who believe in God?
71. Do you ever judge a person by his religious beliefs?

Sin and Punishment:

83. Do most people think you have good morals?
84. Have you ever done things you thought were morally wrong?
85. Do you feel that you have sinned in some way?
86. Have other people ever forced you to live immorally?

From Interview B:

Early Family Life:

1. Did you ever have any trouble with your family?
2. How many brothers and sisters?
3. Did you live with your parents when small?
4. When you were little, whom did you use to take your troubles to?
5. Who ran the family?

Marriage:

40. Had your husband (wife) anything to do with your being here?
41. Have you been worried about your home (children) (spouse)?
42. Did the neighbors make trouble with your family life?
43. Have you ever suspected your husband (wife) of stepping out?

Sex:

49. Have you ever worried about past sexual experiences?
50. Do you think that sex shouldn't be thought of?
51. Did you enjoy sexual contacts before coming to hospital?
52. Is this one of the reasons for wanting to get out?

Chapter 12

TIME-SAMPLING STUDY OF BEHAVIOR

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The present study was undertaken to investigate the usefulness of a time-sampling method for study of the effect of various brain operations upon the behavior of psychotic patients. The procedure was designed to secure measures, before and after operation, of general activity and also of social behavior, that is, activity directed toward other individuals or serving as stimulation to other individuals.

Reports of frontal lobe brain surgery abound in references to changes in behavior, documented in many instances by careful descriptive notes. Terms, more or less general, such as overactivity, restlessness, talkativeness, lack of restraint, dullness or unresponsiveness, appear frequently. Changes in personality and in social behavior following lobotomy have been especially noted by Bennett, Keegan, and Wilbur ('43); Kindwall and Cleveland ('45); Strecker, Palmer, and Grant ('42). W. Freeman and Watts ('42, p. 152) devote a chapter to the social behavior of lobotomized patients and say, in summary:

> It is the overt activity that undergoes an alteration in the direction laid down originally in the personality, but deviated in one way or another by superimposed psychosis. In other words, following operation the patient becomes more natural. He reacts in a direct manner to the environment with a less devious and calculated response.

With the increasing recourse to brain surgery as a therapeutic measure in mental illness and the introduction of different types of operation, reports of behavioral changes have become more numerous. However, there has been no standardized procedure by which objective measures could be secured. As a result, case-to-case comparisons of altered behavior or even direct evaluation of changes in a single individual, rest upon uncertain ground. The determination of changes in such characteristics as general activity and social behavior requires a method that can be tested for reliability and validity, as are the methods for investigation of other phenomena in the fields of psychology and physiology. Where changes in behavior following brain surgery may be related to specific operative procedures, questions regarding the nature, extent, and duration of such changes become of

Visions:

170. How often do you see visions?
171. Do you remember the first time you saw these visions?
172. What did you see?
173. Were you very frightened when you saw this?

The Operation:

195. Have they noticed any change in you since the operation?
196. Are you getting along any better since the operation?
197. What do you think was the main effect of the operation?
198. Do you think the doctors did a good job on you?
199. What did you expect to happen to you after the operation?

PROCEDURE

Patients were introduced into a uniform situation (a room with constant furnishings) and left there for the duration of the session. A single patient was introduced "alone for sessions" (designated A sessions) and a pair of patients were brought in together for the "social sessions" (designated S sessions).

A brief standard introduction was used at each session, explaining to the patient that he would later be taken to one of the staff of examiners for a test and meanwhile would be left in the waiting room. He was told that he might do whatever he wished and that he should feel free to use whatever was in the room, mentioning, for example, the magazines, paper and pencil, and playing cards. As an interesting toy a "Slinky" (a coil of flat steel ribbon) was briefly demonstrated. No patient was scheduled for a social session until half a day or more after his A session. After 20 minutes the session was interrupted by whoever had brought the patient in, who said, "Mr. So-and-so is ready to see you now."

An observer, behind a one-way-vision mirror, kept a continuous record of such behavior as the patient or patients exhibited. Behavior was recorded under 3 major headings: (1) Gross activity: changes of location in the room, getting up from the chair, standing near table, pacing, walking from table to wall, (2) attention to objects: behavior involving objects, reading magazines, writing, using brush and comb, primping, playing with cards, checkers, or toys, (3) segmental acts or self-directed movements: shifts of position of hands, arms, head, or legs, when an individual remained in the same place and was not otherwise occupied, stereotyped movements, scratching, running hands through hair, and the like.

When activity was extremely varied and shifted rapidly, priority in recording was given to items in the first or second category if the patient was alone. In social (S) sessions, priority in recording was always given to verbal or other social behavior, second priority to location, (category 1), and third priority to attention to objects (category 2). With the exception of a few S sessions, there were intervals of relative quiet during the period of observation. During such intervals earlier activities, entered in skeleton form during an active period, could be filled into the record by the observer.

Two rooms in 2 different state hospitals, Greystone and Rockland, were utilized as the "Waiting Rooms" in this study.

Both were furnished with 2 tables, 2 chairs, assorted pictures on the walls, and various "stimulus objects."

The same objects and pictures were used in both rooms but differences in furnishings necessitated some differences in arrangement. The objects on the larger of the tables were: a covered transparent box of candies of different kinds, a box of colored cubes, a box of crayons, a pencil, an envelope and pad of paper, 2 packs of cards in boxes, a "Slinky," a checkerboard and box of checkers, a small toy

special theoretical interest as well as of practical importance, and the need for a method affording accurate measures becomes increasingly obvious. The Columbia Greystone Associates in the course of their initial study, recognized the desirability of more objective recording of postoperative behavior, particularly of general activity. They report:

> Reliable records on the amount of activity in which the patients engaged are not available. It was not until late in the study that we were able to obtain pedometers...and basal metabolic studies were not conducted. There is a distinct impression that the most notable degree of over activity occurred in those individuals from whom the largest number of areas (and largest amount of cortex) was removed. In peculiar contrast to this we know that the measurements we do have on the lobotomy cases demonstrated a definite reduction in the amount of activity. Additional and more precise data are needed to resolve this important question (Pool, et al., '49, p. 436).

The purpose of the present study was to supplement the data obtained by the other research investigators working on this project by securing measures of general activity and of social behavior employing an adaptation of the time-sampling observation method which has been found of value in studies of child behavior. This method has been employed by one of the authors in a 5-year study of behavior characteristics of young chimpanzees (Kinder, '46, '47) and in an earlier study of mentally defective subjects (Kinder and Humphreys, '36). A related study (unpublished) by Young has shown that this method can profitably be used to secure data on behavior characteristics of children classified as prepsychotic.

A comprehensive discussion of methodological problems of time-sampling procedures, including a review of studies bearing upon the questions of reliability and validity, will be found in Arrington, ('43). The technique utilized is very like experimental methods which have been employed in the field of animal psychology (Reed, '47). These animal studies with their contribution to our understanding of mechanisms underlying behavior changes, have depended upon data secured when the subjects were placed in a situation appropriate for eliciting the behavior to be studied; for example, maze-running, nest-building, or "spontaneous" activity. Similarly, the procedure of the present study has depended upon the placing of our subjects in a standard situation with provision for recording their behavior.

The situation used in this study was designed to investigate variety, as well as amount of activity. To this end, opportunity was provided for "general" activity, within limits, as well as for "specific" activity. Due to the exploratory nature and necessary time limitations of the study, emphasis was placed upon securing as extensive a sampling of behavior as possible, rather than upon a specific experimental design limited to the testing of particular hypotheses.

SUBJECTS

The chief factor determining the selection of subjects was the limited time available for the study. Nineteen of the group of 23 patients initially scheduled for operation were included in the study, with at least 2 records each. Seventeen were subjects in both the initial series (-16A) and the final series (+79C). Eleven of the 17 were also seen in the +11B series; and 11 subjects (though not the same 11) were included in one or more S sessions. The number of S sessions for a single subject ranged from one to 5. A total of 63 records were taken. These were distributed as shown in Table 43.

Table 43

DISTRIBUTION OF TIME-SAMPLING SESSIONS

Observation Period	Place	Time	Type of Sessions Alone	Social	Total
Series -16A	Greystone	Oct. 1948	18	5	23
Series +11B	Rockland	Nov. 1948	13	3	16
Series +79C	Greystone	Jan. 1949	18	6	24
Total number of sessions			49	14	63
Total number of patient records			49	28	77

SCORING AND EVALUATION OF RECORDS

After tabulation of the entries for all behavior sessions, a careful study was made of the records of the +11B series taken at Rockland Hospital, where the more accurate method of recording made determination of behavior possible during each 15-second interval of the period. A system of scoring was developed based upon a tentative evaluation of the energy expenditure involved in each of the recorded types of behavior. It was assumed that a greater expenditure of energy was involved in walking than in standing, in standing than in sitting, in raising 2 arms than in raising one, in raising the arm above the head than in arm movements below the shoulder, or in moving an object from one position to another than in making a similar movement without an object. In general, the amount of effort required to counteract gravity was the chief basis for the evaluation. An arbitrary scale was established ranging from one point for minor activities, for example, head turning, finger tapping, to 20 points for vigorous full-body activity such as dancing.

xylophone, and a 4-page leaflet with simple musical scores. Reading matter consisted of 4 magazines (McCall's, New Yorker, Holiday, Life) and a pocket edition of Thurber's Men, Women, and Dogs. On a smaller table were a hairbrush, comb, shoebrush, red-rimmed eyeglasses, and a box of facial tissues.

Three series of records were taken. The first and last series (-16A and +79C) were at Greystone Hospital, where records were taken within a small cubicle, using a stopwatch for timing. The second series (+11B) was at Rockland Hospital where records were taken in a sound-proof room with a special recording instrument. The -16A series included 23 sessions distributed over a 10-day period, beginning October 3, 1948, and preceding the patient's operation by an interval of not less than 2, nor more than 19 days. The 23 sessions, included sessions alone for 18 patients and 5 social sessions, the latter furnishing S records for 10 patients. The +11B series at Rockland State Hospital about 3 weeks later included 13 A sessions and 3 S sessions (6 patient records), the time after operation varying between 7 to 13 days. The +79C series of 18 A and 6 S sessions were completed during the first 2 weeks of January 1949, the period after operation ranging for different patients from 68 to 96 days.

The conditions of the study introduced variables which could not be controlled and whose effect upon our data cannot be determined or estimated. A most serious circumstance was the impossibility of securing more than one series of preoperative records for comparison with later postoperative records. Moreover, in both the -16A and +79C series (Greystone Hospital) the data were secured under serious handicaps arising from the variable amount of noise in the adjacent rooms and corridors and the makeshift character of the cubicle which necessitated utmost quiet on the part of the person recording. Quantification of the records must therefore be considered approximate only. It is unlikely that changes in location (sitting, standing, walking) were omitted from any record. Possible errors in recording the handling of objects on the tables or attention to pictures or other environmental stimuli, would be in the direction of understatement of the activity of patients having the higher scores.

The data of the +11B series, especially, must be considered in relation to uncontrolled variables. These sessions followed shortly after the operations; moreover, the transfer of the patients from one hospital to another necessitated a 2-hour automobile trip. Although no patients were moved until they had sufficiently recovered from the operation to make the trip, condition upon arrival varied. The time-sampling observations were sandwiched in between the neurologic examinations involving rotation and nystagmus which further added to an unusual state in certain patients. Hence, we emphasize that, although more detailed recording was possible than at Greystone, the +11B determinations are of uncertain value.

Table 44

ACTIVITY SCORES FOR INDIVIDUAL PATIENTS WHEN ALONE (A SESSIONS), WITH THE MEANS AND STANDARD DEVIATIONS FOR THE GROUP

Patient Number	Sex	Operative Technique	Series -16A	Series +11B	Series +79C	Mean
B5	F	VL	522	352	470	438
B6	M	VL	275	383	332	330
B7	F	VL	508	558	586	551
B8	F	VL	719	635	375	576
B9	M	VL	39		39	39
B10A	F	VL	224	274	356	265
B11	F	VL		396	402	399
B12	F	VL	186	170	205	187
B13	M	TH	237		471	351
B14	M	TH	517		201	359
B15	F	TC	515	398		456
B16	F	TC	110		368	239
B17	F	TO	171	327	177	225
B18	F	TO	399	232	430	354
B19	M	TO	169		198	183
B20	M	TO	355	314	363	344
B21	F	TO	401	319	194	305
B22A	F	TO	203	400	396	333
A10	M	TO	409		184	297
Mean			331.06	366.00	319.28	327.95
SD			174.7	119.1	134.5	124.7

others (B8 and B21) successive decreases. In general the entries in Table 44 show little difference between the mean scores of the -16A and +79C series. The range of scores and variability are less for the +79C series than for the initial series, however, individuals with high or low initial scores tend to retain that relative position. A statistical regression toward the mean is to be expected in data where the initial scores are based upon a single period of observation of behavior in an unfamiliar situation. That individuals differ widely in their response to a novel environment (some being stimulated to increased activity and others being inhibited) is generally recognized and has been experimentally demonstrated in studies of animals and children. That

Anchoring points between 1 and 20 were established and ratings for specific activities were assigned around these anchoring points. Because entries were in terms of 15-second periods, the score for continuing activities was the sum of the values for the successive 15-second units through which the activity lasted. Values were cumulated in the case of complex activities. For example, leaning over the table while writing with one hand is given a score of 2 for standing, 5 for leaning forward, and 4 for the continued use of the pencil, a total of 11 points for every 15-second interval during which this activity is continued. Single acts (changing position) were scored once only, for example, (patient seated) 2 points for shifting arm position to place elbow on the table, arm flexed, and head supported by hand, or 5 points for rising from a chair to standing. Clasping hands in lap received a single score of 4 points, whereas clasping hands behind head, assumed to require more energy, was given a score of 6. The total activity score for each record was the sum of the scores of the separate entries. In brief, the activity unit, arbitrarily assigned by this scoring system, was used as a common denominator for the varied activities engaged in by our subjects, thus affording a basis for comparing individual records or groups of records.

Total activity scores indicate only the amount of activity during a session; they afford no information regarding the pattern of behavior. Two similar scores, for example, might represent in one case many single acts; in another, a smaller number of more complex activities. To investigate this aspect of the time-sampling sessions the entries of records were tabulated according to defined behavior categories for study of the patterns of behavior of different patients and of the same patient at different times or under different circumstances.

As a final step, all records were studied for evidence of inappropriate, stereotyped, or bizarre behavior, on the one hand, or of exploratory, goal directed, or other adaptive behavior on the other hand. Social records were studied especially to determine characteristics of patient interaction.

RESULTS

TOTAL ACTIVITY SCORES, A SESSIONS: Of the 19 patients included in this study 17 were subjects in both the -16A and +79C series. Eleven of these were also subjects in the +11B series.

Examination of the scores of individual records in Table 44 reveals a range from 39 to 719 activity points in the -16A sessions. There were irregular increases and decreases in the activity scores of individual subjects ranging from a gain of 258 points for patient B16 to a loss of 344 points for patient B8 between -16A session and the +79C session. There was no consistent trend from series to series, and no clear relationship to operative procedures, the changes in one direction balancing in number and amount those in the opposite direction. Two patients (B7 and B10A) show successive increases, and 2

and no indication of relationship between the 2 measures. No relationship was found between activity scores and differences in length of illness as indicated by date of first hospitalization. Moreover, except for 3 patients diagnosed as schizophrenia, paranoid type, there was no suggestion of relationship between activity scores and diagnostic category.

The ages of 13 patients range from 26 to 36 years; the ages for the remaining 4 range from 45 to 52 years. The difference in mean age of the 2 age subgroups is 17 years, and is statistically significant. Although not statistically significant, there was a corresponding difference between the mean activity scores of the age subgroups, the older patients having scores that were generally higher than those of the younger group.

Table 45

ACTIVITY SCORES (A SESSIONS) AS RELATED TO SEX, AGE AND OPERATION

	Age	Sex	Operative Technique	−16A Score	+79C Score	Change in Score	% Change in Score
Younger							
B6	32	M	VL	275	332	+57	+38
B9	36	M	VL	39	39	0	0
B19	34	M	TO	169	198	+29	+17
B20	27	M	TO	355	363	+8	+2
B13	32	M	TH	237	471	+234	+100
B14	26	M	TH	517	201	-316	-70
Means Male				265.3	267.3		
B7	35	F	VL	508	586	+78	+15
B12	26	F	VL	186	205	+19	+10
B17	33	F	TO	171	177	+6	+3
B18	28	F	TO	399	430	+31	+8
B21	33	F	TO	401	194	-207	+51
B22A	33	F	TO	203	396	+193	+95
B16	30	F	TC	110	368	+258	+235
Means Female				282.5	336.5		
Means Younger Patients				274.6	304.6		
Older							
A10	45	M	TO	409	184	-225	-56
B5	51	F	VL	522	470	-52	-10
B8	47	F	VL	719	375	-344	-48
B10A	52	F	VL	224	356	+132	+59
Means Female				488.3	400.3		
Means Older Patients				468.5	346.2		

the means of the activity scores remain relatively constant in spite of this decrease in range and variability indicates the consistency in the behavior represented by these measures. Consistency is further indicated by the positive correlation of +0.41 for the -16A and +79C records. This correlation is lower than the value required for statistical reliability, but is important in view of the small number of cases and the large number of variables in the study.

For the 11 subjects for whom 3 series of records are available, the mean scores are 360.3, 360.4, and 353.1 respectively. The variability of the records of the +11B series (these were taken shortly after operation and under quite different conditions than those of the other 2 series) also corresponded closely to that of the -16A series. However, rank-order correlations of the scores of the 11 subjects for the 3 series indicate a closer relationship between the -16A and +79C series taken at Greystone (+0.60) than between either of the other pairs (the value for 2 postoperative series, +11B and +79C, being +0.38, for the -16A and +11B series, being +0.46). The number of cases is small and the values are not statistically significant, but they indicate that when the scores of the individual subjects are considered the +11B records are less comparable to the initial series than might be inferred from the group measures. The differences may be due to the special method of recording used in the +11B series, or they may indicate that the time-sampling method as a whole is sufficiently sensitive to reflect behavior changes resulting from the unique conditions of the Rockland series. Observation of the patients in other than the time-sampling situation would tend to support the latter possibility.

Because of the higher correlation between the scores of the -16A and +79C series, and also because of the greater number of subjects for whom those pairs of records were available, the data of these series were used for further investigation of possible relationships between activity scores and other variables represented in our groups of subjects, namely, sex, IQ, length of time in the hospital, chronological age, diagnostic category, psychiatric findings, and type of operation.

Of the 17 patients for whom -16A and +79C activity scores were available, 7 were males and 10 females. Examination of our data for possible sex differences showed that although the number of patients in each group was small and the differences in scores within any series were not statistically significant, the females were consistently more active than the males. This is in line with the common impression that female patients in mental hospitals are generally more active than male patients. The possibility of a sex difference in general activity, as determined by this method, must be kept in mind in evaluating the data for individual subjects.

The intelligence level of these subjects has been reported in detail in Chapter 9. The IQ's of 9 patients ranged from 55 to 80; for the remaining 8, from 85 to 114. The difference of 32 points between the mean IQ of the VL and TO patients is statistically reliable. There is no corresponding difference between the 2 groups in activity scores

and no indication of relationship between the 2 measures. No relationship was found between activity scores and differences in length of illness as indicated by date of first hospitalization. Moreover, except for 3 patients diagnosed as schizophrenia, paranoid type, there was no suggestion of relationship between activity scores and diagnostic category.

The ages of 13 patients range from 26 to 36 years; the ages for the remaining 4 range from 45 to 52 years. The difference in mean age of the 2 age subgroups is 17 years, and is statistically significant. Although not statistically significant, there was a corresponding difference between the mean activity scores of the age subgroups, the older patients having scores that were generally higher than those of the younger group.

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B10A	52	F	VL	224	356	+132	+59
Means Female				488.3	400.3		
Means Older Patients				468.5	346.2		

Inspection of Table 45 which relates changes in A score to age, sex, and type of operation supports the following observations. (1) Only one patient aged 36 or less showed a decrease in activity while 3 out of 4 over 36 did show a decrease. Proportionally large changes are more frequent in the older groups. (2) There is no clear relation between change in score and the type of surgical technique employed. It should be noted that one thalamotomy patient (B13) increased 100 per cent in activity while the other (B14) decreased 70 per cent; also that the TC patient (B16) increased 234 per cent.

TOTAL ACTIVITY SCORES, S SESSIONS: Records of social sessions were studied, not only for evidence of specific social behavior, but also for indication of possible effects of the presence of a second subject upon general activity. Eleven patients, 3 males and 8 females, participating in 14 sessions, provided 28 individual social records, distributed among preoperative and postoperative series, as shown in Table 43. Partners were always of the same sex.

Only 9 pairs of patients were included, 4 for a single session only, 5 for sessions in 2 series each, (once in the +79C series, and earlier, in either the -16A or +11B series). Time limitations and availability of patients determined the pairs seen in the -16A series, and were responsible for the fact that only 2 patients of the VL group were included. These 2 patients had only one session each, because both were initially paired with patient B15, who was too disturbed at the time of the +79C series for inclusion in the time-sampling study. None of the pairs seen in the -16A series was repeated in the +11B series because in no instance were both partners of any of these pairs brought to Rockland Hospital on the same day. Our data thus constitute about a 10 per cent representation of the 21 possible pairs of male subjects and the 66 possible pairs of female subjects within the group of 19 patients for whom 2 or more A records are available. Nevertheless, they afford the following comparisons: (a) activity scores in social sessions with scores when alone (11 subjects, 57 records); (b) scores in social sessions for the same subject with different partners (5 subjects, 19 sessions); and (c) scores of the same pair of subjects at different times, that is, in different series (5 pairs, 10 individual records, 7 different subjects).

Table 46 gives mean activity scores and measures of variability of S sessions as compared with A sessions for 5 individual patients, each a participant in 3 or more S sessions. These data indicate that, quite apart from specific social behavior as such, the presence of a second patient tends generally to reduce the activity score. The mean of all 28 S records was 278 ± 162; the mean for the 29 A records of the same subjects was 325 ± 143. The lower scores in the S sessions might be attributed to the difficulty in taking records of 2 patients, were it not for the wide range of scores in the social sessions and the circumstance that some S records have high activity scores (one of them higher than any A record). Moreover, no S records were taken until a

Table 46

COMPARISON OF MEAN ACTIVITY SCORES AND MEAN DEVIATIONS FOR A AND S RECORDS FOR PATIENTS FOR WHOM 3 OR MORE S RECORDS WERE OBTAINED

Patient	Operative Technique	A Records No.	A Records Mean ± M.D.	S Records No.	S Records Mean ± M. D.	Diff. Between Means	Per Cent Reduction in Mean Score
B20	TO	3	344 ± 20	4	299 ± 168	45	13
B21	TO	3	305 ± 74	5	263 ± 61	42	13
B22A	TO	3	333 ± 87	4	231 ± 99	102	30
B17	TO	3	225 ± 68	3	138 ± 32	87	39
B15	TC	2	456 ± 58	3	251 ± 77	205	45

series of A records had been completed and facility in record-taking had been acquired. In general, the scores are believed accurately to reflect activity differences, and the fact that in many social sessions movement about the room was less than in A session.

Although for every one of the 5 subjects having 3 or more S records, the mean activity score of these records is less than for the corresponding A records, the extent of the difference varies greatly for individual subjects. Patient B20 had the greatest variation in S record scores and the least in A scores.

The data of Table 46 include all S records for the patients there reported, disregarding possible relationships to operative procedures and to the additional variables of the +11B series. To investigate the extent to which the variability found in Table 46 may be influenced by other conditions than the presence of a partner, it was necessary to examine the scores for all pairs of subjects seen on more than one occasion. These data are given in Table 47, including data for 3 patients paired with more than one partner where both pairings were repeated.

Table 47 shows clearly that in S records, as in A records (Table 44), there are irregular gains and losses when scores of one series are compared with those of another. The data also show (1) that the presence of a partner does not affect the activity score in uniform manner, (2) that the generally lower mean scores appearing in Table 46 only partially represent the data of the social sessions, and (3) that for specific social sessions there are wide discrepancies between the S score and the corresponding A score.

For individual patients, differences in activity score between the +79C series and earlier series are generally in the same direction for social sessions and sessions alone. Only 3 of 10 records show a difference in the direction of change, and in every case the score of the S session shows a decrease, while the score of the corresponding A session shows a gain. In many instances the differences between either the S records of the 2 series, or the corresponding A records, are slight; nevertheless, decreases in score are more common in the social records; increases, more common in the records alone.

THE ACTIVITY SCORE DATA, SUMMARY A AND S. There are marked individual differences in activity scores of individual patients placed in a standard situation, both when alone and with a partner. There is greater consistency in the records alone, patients with high scores or low scores tending to remain in those general categories. Of 17 patients included in sessions alone 16 days prior to operation and again 79 days after operation, 9 showed only slight changes in score (not over 17 per cent of the initial score), while 8 showed considerable change (38 per cent or more, equally divided as to direction). The larger changes were more frequent in patients of the older age group. No large changes occurred in younger patients of the VL group; large changes did occur, however, in the 2 TH cases, the one TC case studied, and 3 of the TO cases.

Table 47

ACTIVITY S SCORES OF PATIENTS WITH DIFFERENT PARTNERS AND FOR THE SAME PAIR OF PATIENTS AT DIFFERENT TIMES

				A Score					S Score			Comparison of A and S	
Patient	Operative Technique	Sex	Age	-16A	+11B	+79C	Direction of change -16A to +79C	Patient Partner	-16A	+11B	+79C	+11B	+79C
B20	TO	M	27	355	314	363	+	B13	423		511		+
								B19		140	121	-	-
B17	TO	F	33	171		177	+	B21	155		91		-
B19	TO	M	34		169	198	+	B20		97	497	-	+
B21	TO	F	33	401	319	194	-	B17	323		292		+
								B22A		325	217	+	+
B22A	TO	F	33	203	400	396	+	B16	391		66		-
								B21		270	198	-	-
B13	TH	M	32	237		471	+	B20	400		478		+
B16	TO	F	30	110		360	+	B22A	157		342		-

Data on activity scores in sessions with a partner, though limited to a 10 per cent sampling of possible combinations, indicate greater variability than for patients alone. Changes in score between earlier and later sessions are generally in the same directions as changes in the scores of the corresponding sessions alone, but marked changes are less frequent.

PATTERNS OF BEHAVIOR. Analysis of records to determine individual characteristics of behavior, or distribution of emphasis was accomplished by tabulating the entries for each of the 7 categories, sits, stands, walks, self-directed acts, object contact, magazines, other environmental stimuli. The uniqueness of the individual was expressed clearly by these patterns of activity; in fact, there was so little correspondence that no classification of the records on the basis of pattern was possible.

For a few individuals the records of all A sessions were much alike; marked variation in the A records of any individual was uncommon. In contrast, records of S session (though similar among themselves) differed considerably from the A records of the same individual. One difference common to many patients in S records was a marked reduction in "autistic" or self-directed activity such as head or body scratching, sustained grooming etc., which the patients were more apt to exhibit when alone. Except for an increase in the amount of standing and walking in either or both the +11B and +79C records of a few patients no change in pattern of activity was found to follow the operations.

SPECIFIC FORMS OF BEHAVIOR. There were few instances of unusual or inappropriate behavior other than talking aloud while alone. Two women showed considerable ingenuity in manipulation of the "Slinky." One patient played solitaire during the -16A and +11B session but not during the +79C session. Several patients used the pencil or crayons or paged through the magazines. Yet compared with the diversity of opportunity the range of behavior of the individual patients was narrow at each session.

Social behavior was not frequent. The partners under observation watched each other more or less openly from opposite ends of the room. No physical contact was noted at any time, and never were the partners even comparatively close (as when one offered candy to the other) for longer than 30 seconds. Social gestures included offering the preferred chair, a magazine or object, making favorable comment on appearance or ability, or other small bits of conversation. Verbal interchange occasionally continued for a minute or 2. In many sessions, however, no single instance of social interaction occurred. Nevertheless, the reduction in general activity indicates that these patients were sensitive to the presence of a partner, a finding that could hardly be established without the basis for comparison afforded by the records of activity in sessions alone. So far as could be deter-

mined, no one of the measures of social interaction was affected by the operative procedures.

DISCUSSION AND SUMMARY

Reports of clinical observation have indicated that frontal lobe operations were frequently followed by changes in the amount of activity of the patient. Studies by Richter and Hines on lower primates have measured increases in motor activity following frontal lobe operations. The method employed in the present study has provided us with a limited time-sample of the activity of individual patients before and after one or another of 4 types of psychosurgery. A system for quantifying the samples has been established. In spite of unsatisfactory experimental conditions we have been able to reduce the records to a meaningful picture and to indicate where the major lines of cleavage probably will be found.

Increases in activity were more common in patients less than 40 years of age and decreases in activity were more common among those over 40. *Certain of the operations undoubtedly involved more neural* tissue than others, while vastly different sections of the frontal portion of the brain were involved in the operations performed on different patients. We found no consistent evidence that changes in activity as determined by this study were related to the amount or location of the neural tissue involved in the operation. However, the largest percentage changes in activity score were found in 2 thalamotomy cases and one case of thermocoagulation. No one of the patients on whom we have presented data showed clear evidence of remission from psychosis during the period of our study.

Differences were found between activities in Alone sessions and Social sessions. These differences were usually decreased activity on the part of both patients in the Social sessions in comparison with the activity shown by either patient while alone. So far as we could tell from these data the decreases were due in part to less movement about the room and in part to an inhibition of "autistic" activity, such as head or body scratching, random movements and the like, which the patients were more apt to exhibit when alone.

Study of the patterns of behavior represented by the records and of various forms of behavior, including specific social behavior revealed no indication of effect of operation.

It is our opinion that this method is a promising one which may shed light on the changes brought about by psychosurgery if it can be carried out more completely and under more favorable conditions of experimentation.

Chapter 13

PSYCHOPHYSIOLOGY

Henry Eugene King and Johs Clausen

Cortical surgery in human cases furnishes a rare opportunity to observe whether or not such alteration of brain structure is accompanied by changes in the status of the individual. In addition to the measures of higher psychologic functions described in the previous chapters psychophysiologic functions of the individual have been investigated.

The discipline of psychophysiology is concerned with the study of the quantitative relations between a stimulus and the ensuing sensation or experience. Most certainly it is desirable to observe any possible changes in these relationships resulting from the alteration of frontal brain structure. This type of measure, despite its current widespread use in other connections, has been employed very little in the appraisal of frontal brain damage.

Although one might not expect marked sensory change to result from frontal damage on the basis of present day concepts concerning the localization of sensory function in the brain there remains adequate reason for the investigation of these psychophysiologic functions. These functions are among those capable of the greatest degree of precision of measurement in psychology and because they are subject to fine measurement might be expected to reflect more sensitively the status of the individual. It is, of course, realized that these measures do not reflect a total picture of the "psychology" of an individual, they are, however, psychologic in nature, and in addition to the advantage of rather precise measurement they are not too susceptible to improvement as a result of practice. These sensory functions are undoubtedly basic and alteration in their usual function might well have consequences in activities at higher levels, such as comprehension and synthesis.

It is characteristic of psychophysiologic measures that they may be stated in terms of stimulus intensity. It is reasonable, therefore, to seek a relation of the amount of tissue damage to such measures, as well as the specific area of the brain involved. Furthermore, if it should be the nature of brain tissue to act in a non-specific way or as a whole then a possible alteration in the intensity characteristics of one sensory field may well correlate with such alteration in another.

We have attempted to obtain reliable indices of an adequate sampling of the individual's sensory make-up which could be expected to

reflect any alteration in the sensory processes which might result from frontal damage.

There are available, of course, many tests of sensory function. We have attempted to select some of the best and most representative of these from each of the various senses. Since our patient population was made up of psychotics it was necessary to select tests of as simple and direct a nature as possible so as to obtain a certain ease of measurement which might add to one's confidence in results obtained. The fact that many of the tasks selected are visual in nature is not so much a reflection of the greater importance of this sense to the individual as the fact that this modality lends itself to many different types of measurement and has been a primary focus in the field of psychophysiology.

The final battery of examinations or tests employed were as follows:

Visual Acuity
Peripheral Visual Fields
Perception Time
Spaced Perception
Visual Intensity Discrimination
Critical Flicker Fusion: Stroboscopic
Critical Flicker Fusion: Episcotisteric
Pain Threshold
Audiogram
Motor Response Time
Motor Tapping Speed
Finger Dexterity

DESCRIPTION OF THE TESTS EMPLOYED

VISUAL ACUITY. An obvious factor to examine before proceeding to other details was the patient's visual acuity. Since one of our primary interests lay in the knowledge of the patient's visual acuity before proceeding to other measures a simple clinical examination with Snellen visual acuity charts was employed. The test was carefully made at each testing interval, however, and is capable of reflecting possible alterations in this function within the limits of the sensitivity of this type of test. Both eyes were tested in the standard manner without the help of correction by eye glasses.

PERIPHERAL VISUAL FIELD. A plot of the peripheral visual field of each eye was made employing a Brombach perimeter, an instrument which gives uniform target illumination in all meridians. A one degree white target was used at all times, and especial care was given to making sufficient readings proceeding both into and out of the field to allow for the greater latency of response in some psychotic patients. Examination was conducted for 8 meridians on each eye including the

vertical, horizontal, and crossing axes (cardinal and midpoint meridians).

PERCEPTION TIME. This is a measure of the time which elapses from the presentation of an object to its recognition by the observer. Visual stimuli were utilized because of the facility with which this material can be handled. The apparatus designed especially for this type of stimulus presentation is the tachistoscope. In essence this consists of an exposure field at suitable distance from the eyes, a method for briefly exposing stimuli upon this field and proper design to allow for fixation of the eyes and the elimination of after-images. The subject centers his attention on a fixation point which is placed in the center of a stimulus field. A "ready" signal is given following which the fixation point is replaced—practically instantaneously—by a simple stimulus, a letter or a number, which remains in the stimulus field for a predetermined length of time. The subject is asked to report what he has seen. The task is begun with a stimulus object of 3 numbers which is exposed for 10 milliseconds. This interval was deliberately chosen as being too short an exposure to allow for perception by any subject at the level of illumination maintained in the apparatus. The stimulus is then presented again for 20 milliseconds and again at intervals increasing by 10 milliseconds at each exposure until the subject was able to report the stimulus correctly. An identical procedure was followed for 3-letter stimuli.

PERCEPTION OF SPACED STIMULI. It was of interest to observe to what extent brain-operated patients could perform a task which required attention to more than one stimulus. In the previous test our concern was with stimuli of a fixed complexity at varying exposure times. Another test which can be made with the same apparatus is that of perception at a fixed exposure interval of increasingly more complex stimuli. Our method of complication was to utilize stimuli of one number and one letter which are progressively spaced further and further apart with each succeeding exposure. The stimulus patterns are so arranged that one element of the stimulus was located at the same point in the stimulus field as the fixation point and the other was displaced horizontally either to the right or the left of this point. A given distance between the 2 stimulus components was always used twice, once with the more peripheral component to the left and once with it appearing on the right. Any given number-letter combination was used only once. The distance between the 2 components was increased in a standard fashion with each exposure until the subject failed to report both stimuli correctly.

Although it has been stated that this task is performed with exposure time held constant, it is possible to utilize several different standard intervals and to run through a series of increasing complexity for each standard interval. We have obtained data with this method utilizing standard intervals of 100, 120, and 150 milliseconds,

all of which are below reaction time for refixation of the eyes thus eliminating the possibility of the subject looking first at one component of the stimulus and then at the other.

CRITICAL FLICKER FREQUENCY. This phenomenon, which belongs in the category of those sensory experiences which are aroused by intermittent stimulation such as vibration or flutter, is more easily measured and for this reason was chosen for inclusion in our battery. In the visual sense there is a considerable range within which repetitive stimulation possesses a "flickering" character. Above this range the rate of stimulation is so high that the separate stimuli are indistinguishable as such and it appears to the subject as if stimulation were perfectly continuous or fused. The point at which this change in sensation occurs is called the fusion point.

Determinations were made of this point by 2 different methods. (a) Stroboscopic. A General Radio Co. Type 631-B strobotoc was mounted in a box so that it illuminated a milk glass screen 2-1/2" in diameter. This instrument is essentially a neon lamp which may be flashed at various rates. The speed of flashing of such a lamp may be regulated to give a selection of frequencies through the range required for human flicker measurement. A simple conversion permits recording in terms of cycles per second (cps), the unit in which critical flicker frequency is usually reported. The test was carried out in a room with standardized illumination, and the brightness of the stimulus field at approximate threshold value was 7.844 millilamberts. The subject was seated 2 feet distant from the screen so that the field was viewed by central fixation of the 2 eyes.

Establishment of the fusion point was made by the method of limits. The subject was instructed to look at the obviously flickering field and was told that the rate of flashing would be increased until the field appeared to be no longer flickering but would seem to be quite steady. He was to report the point at which he first experienced the sensation of continuous illumination. A reverse procedure was then followed in which the subject reported the point at which flicker was first experienced. A number of judgments were obtained using these approaches alternately so that an average could be obtained for the transition from "flicker" to "steady," from "steady" to "flicker" and an average of these 2. The stroboscopic method is an extremely simple one and for this reason is easily applied in the clinical situation. It does not, however, bring under control many of the experimental factors which are known to relate to the phenomenon.

For this reason we also employed, (b) Episcotisteric apparatus for the obtaining of the fusion point which does take into account these several factors. This measure, while more exact, was more difficult to obtain, and for this reason we employed both tests, so that we might have at least the simpler measure on those cases unable to perform the more exact but also more complicated measure. The primary advantage of this second method is that it provides exactly equal intervals

of light and dark at all frequencies of transmission. It is known that the fusion point is a function of intensity of the stimulating light and it is also known that the apparent brightness of a light is a function of the ratio of the light and dark intervals which make it up, therefore it is important to maintain a constant ratio of light and dark intervals at all frequencies utilized in order not to affect the fusion point by this factor.

We have employed the fact that fusion point is a function of stimulus intensity to make measures sampling the range of human flicker response. Working backwards from what is known of the normal human response we set 3 stimulus levels at which to obtain fusion points: one low or dim illumination, (0.013 millilamberts at exit pupil) one medium (0.410 ml.) and one bright stimulus (1.296). Our reason for so doing is the fact that the relation of fusion point to illumination plots as a simple growth curve which becomes asymptotic over a protracted range as the higher levels are reached; therefore we needed measures from various points on this curve so that any possible alteration of this function would have maximum opportunity to reveal itself. Several other advantages of our more complicated method are that: the stimulus is viewed monocularly and by central vision, that the eye may view the field with accommodation for infinity, and an exit pupil equates individual differences in pupil diameter.

The optical system contains the following essential elements: a light source, a means of making this source intermittent, a filter container, a focusing lens, and an exit pupil. As a parallel system there were attachments made so that the frequency of the intermittent flashes might be read at any given moment.

Figure 53 is a schematic diagram of the apparatus employed.

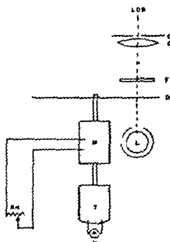


FIG. 53. Diagram of the episcotister apparatus.

In order to have the eye properly dark adapted for the stimulus level in use the following procedure was observed. The subject wore

The light source (L) was provided by a 40-watt frosted lamp operated on 110 volts, 60-cycle current. Light rays passed from the source through a small circular opening. The brightness of the source, as measured through this system was 4100 millilamberts for maximal transmission. Directly in front of the light was a disc (D) which alternately interrupted and allowed passage of the beam of light from the source. The disc was made up of 2 90-degree sectors alternating an open and a closed sector in the line of sight (LOS). One revolution of the disc, therefore, allowed 2 cycles of equal duration light and dark intervals to pass through the system. Frequency of the intermittent stimulus could be determined by the speed of rotation of this disc.

A filter mount (F) allowed systematic reduction of illumination from the source by the insertion of Wratten neutral tint filters (density combinations used: 5.5, 4.0, and 3.5). After emerging from the filters the beam of light fell upon a 5.5 diopter double convex focusing lens (C) placed at focal distance from the stimulus field, which was the frosted surface of the lamp. Light waves coming from the stimulus field passed through the lens and emerged parallel so that the eye might view the field with accommodation from infinity. An exit pupil (E) in front of the lens provided a 4-mm opening at the center of the lens. The stimulus field, as viewed through the exit pupil, subtended a visual angle of 3.75. The entire system was light tight to prevent the entry of stray light and painted dull black to keep internal reflections to a minimum.

The disc which interrupted the beam of light from the source was mounted on a small electric motor (M). This operated on 110 volts, 60-cycle AC and was of such construction that it would run smoothly at the slow speeds required. Speed was controlled by changing the voltage delivered to it by a Variac (RH), which could be regulated by the experimenter. The motor was coupled directly to a small tachometer magneto (T) which produces DC voltage proportional to its speed of rotation. A voltmeter (V) in circuit with the magneto indicated the amount of voltage produced. The speed of the motor, therefore, was the same as the speed of the rotating disc and the speed of the magneto.

The speed of the motor at given voltage settings was determined by the use of a stroboscope, and a conversion table drawn up which indicated directly by reference to the voltage reading the frequency of the intermittent stimulus.

a pair of dark adapting eye filters (Corning No. 2403) for a period of at least 20 minutes and then sat in complete darkness for 5 additional minutes without the filters prior to testing at the lowest level of illumination. When succeeding brighter levels of stimulus intensity were used the subject looked at the stimulus field for a minimum of 1 1/2 minutes to light adapt properly before any judgments were required. Determinations for all 3 levels of stimulus brightness were made using only the right eye.

For all measurements the instructions given the subject were the same as those described above for the stroboscopic method, and similarly the method of limits was employed in making all determinations.

VISUAL INTENSITY DISCRIMINATION. Much of psychophysical measurement is concerned with the perception of differences in the intensity of a stimulus. The previously described phenomenon of flicker

fusion is one aspect of such perception, but much more common is the situation in which 2 matched stimuli are considered, one remaining constant while the other is varied and a judgment rendered at the point at which the subject is able to see a difference or discriminate between the 2. We were interested in obtaining measures of this type, and hence included a test of visual intensity discrimination.

Discrimination in this test was the ability to detect a "just noticeable difference" in the brightness of one half of a bisected circle appearing on a stimulus field as compared to the other half which was maintained at a constant level of illumination.

The bisected circle which was to serve as a stimulus field was mounted on a glass slide. One half of the circle was of polaroid film and the other half was of photographic film. The purpose of the photographic film was to bring this half of the stimulus field to an equal density with the polaroid half, since a certain degree of density is characteristic of polaroid. This stimulus field was illuminated by a 40-watt frosted bulb utilizing 60-cycle AC at 110 volts placed at a distance of 7 inches from the field.

A movable circle of polaroid (H filter No. 330) was introduced between the light source and the stimulus field which was large enough to cover both halves of the field. By rotation of this movable polaroid with respect to the stationary polaroid section the intensity of one half of the stimulus field might be varied. The angular rotation of the movable polaroid could be read from a graduated scale, on which zero degrees represented maximum transmission. A filter container was also mounted between the light source and the stimulus field so that by the introduction of standard filters systematic decreases might be made in the amount of light falling upon the total stimulus field. Filter density combinations of 4.0, 3.0, and 2.0 were utilized.

The eye piece through which the stimulus field was sighted contained a 12 diopter collecting lens placed against the stimulus field and a 5.5 diopter focusing lens at the eye piece. The stimulus field was in the focal plane of the focusing lens such that emerging rays were parallel and accommodation was for infinity. An exit pupil of 4 mm-diameter was attached to compensate for individual differences in pupil diameter. The intensity of the light source as measured through the sighting eye piece was 820 millilamberts for maximal transmission through the system. As viewed through the eye piece the diameter of the bisected circle subtended 6 degrees of visual angle, and the total field in which the circle was placed subtended a visual angle of 9.6 degrees.

The entire system was light tight to prevent the entry of stray light and painted dull black throughout to keep internal reflections to a minimum.

The amount of increase necessary to perceive a difference in the 2 halves of the stimulus ("just noticeable difference" or JND) is known to bear a relation to the intensity of the stimulating light. Our measures were made at 3 levels of stimulus intensity selected from what is

known of this function in the normal subject. Greater increments are needed to perceive difference at higher intensities than at lower. We have, therefore, selected as sample measures a stimulus of low or dim illumination (.082 ml), one of medium (0.82 ml) and one very bright (8.20 ml) stimulus.

The first step in the procedure was to determine the equation point or point at which the subject judges the halves of the stimulus target to be of equal brightness. The method of limits was used to determine this point at the lowest level of illumination and this point was used for all 3 levels of stimulus intensity. Once this point had been determined the instrument was set at this point and the variable half was systematically increased until the subject reported being able to discriminate between the 2. Several determinations of this sort were made at each level of stimulus intensity.

In order to have the eye properly adapted for the stimulus level in use an identical procedure to that described in measuring flicker fusion was followed. Determinations for all 3 levels of stimulus brightness were made using only the left eye.

AUDIOGRAM. As a primary tool in the evaluation of auditory acuity we have plotted the audiogram of each subject as determined with a Western Electric 2A Audiometer. This instrument covers a range of pure tone frequencies extending from 64 to 8192 cps in 8 steps. Our particular instrument was modified to produce also a pure tone of 13,000 cps since we desired to measure of the highest frequencies which it is feasible to determine. The standard procedure recommended for use with this instrument was followed rigorously. All determinations were made in a sound-deadened room, the left ear being used throughout.

PAIN THRESHOLD. In order to determine the amount of stimulation necessary for the subject to experience pain we have employed the method described by Hardy, Wolff, and Goodell ('40). This technique makes use of radiant energy as the stimulus for pain; the amount of stimulation required to reach this point being expressed in terms of the radiant energy at the surface of the skin. All measures were made on the skin in the region of the flat surface of the right forearm. This divergence from the usual procedure of using the forehead as the area of stimulation was occasioned by the fact that our subjects were to have cranial surgery, and the forearm was selected as our next best alternative since we wished to avoid the complications of interference by bandages, possible circulatory disturbance, etc.

The skin was blackened with drawing ink to insure maximum absorption of the radiant energy. The region so treated was placed

against the orifice of the apparatus containing the light source and when the stimulus lamp had been set at the desired intensity a shutter was opened allowing light to fall on the skin for exactly 3 seconds. Successive stimulations were spaced at intervals of one minute.

At the beginning of the test the subject was told that he would not be harmed or inconvenienced in any way and that the purpose of the test was to determine the point at which heat sensation suddenly draws into a brief, sharp jab of pain just at the end of the 3-second exposure. It was described to the subjects as comparable to the sensation experienced from a light pin prick. In all cases sufficient rechecking was done to verify the thresholds so determined.

TAPPING TEST. In addition to the several sensory measures described above we wished to obtain indices of motor function. The simplest of these is the Tapping test. The subject was seated facing a board on which was mounted 2 metal plates (2" x 2" square) placed in a horizontal plane at a distance of 12" between their inner edges. Midway between the places was a wooden barrier 1/2" wide raised 1/2" above the surface and extending across the board.

The subject was placed so that his right arm bent at the elbow, was suspended above the midpoint or barrier. He was told to place his right index finger on the barrier and at the starting signal from the examiner to begin tapping as rapidly as possible between the 2 plates until signalled to stop. The placement of the midline barrier required an arc of movement to be used between the 2 plates.

Measures were taken of the number of taps which could be made in a 5-second interval. Taps were recorded by contact of the finger with the plate by means of an electronic relay system, these taps being recorded on a Veeder counting machine.

FINGER DEXTERITY. As a measure of the extent to which the subject could use his fingers for fine movement we employed the Purdue Pegboard developed by the Purdue Research Foundation, (Tiffin and Asher, '48). This is a standard test widely used in industry, which obtains a measure of small finger movements with left and right hands individually and when the 2 are used simultaneously. The subject is required to place small pegs in holes as rapidly as possible with first the right hand, then the left and then using the 2 simultaneously. He is also required to make assemblies of small parts (pegs, washers, collars) in a designated fashion using both hands as rapidly as possible.

RESPONSE TIME. To obtain a measure of the most rapid response of which the subject was capable under uniform conditions a measure was made of the amount of elapsed time between the onset of a stimulus and the required response. All measures were made using the right hand placed at a standard distance from a response key. Both visual and auditory stimuli were used separately. The subject was told that when the stimulus was given he was to depress the key as

rapidly as he could. A "ready" signal was given by the examiner from one to 2 seconds preceding the stimulus. The apparatus was so constructed that at the onset of the stimulus a chronoscope was activated which continued to run until the response key was closed, yielding a direct measure of the time interval involved. Several readings were made using each type of stimulus, and an average obtained for response to visual and to auditory stimuli.

SELECTION OF CASES AND EXPERIMENTAL DESIGN

It is apparent that with the series of tests described above a rather high level of attention and effort is required to perform the assigned tasks. In a population of mental patients one would not expect to find that all individuals are able to apply themselves to the task in an equal fashion. Since it is of primary importance to be dealing with reliable data we have retained for complete study only those cases whose performance was not clouded by their mental state. Our method for determining eligibility was as follows:

1. All patients included in the project were seen in a survey and were given our simpler tests. Their application to these tasks and suitability as subjects were independently observed and rated by each of the authors. This rating was not based on test results, but upon such aspects of the test situation as cooperation, attention, grasp, effort, etc. These ratings were then combined and the patients were classified as acceptable, questionable, and not acceptable.

2. Those patients classified as acceptable and questionable were then examined with our more difficult tests and once again their suitability as subjects was independently rated. After these ratings had been combined the final group of patients for complete study was selected. Any interesting cases, unable to meet the regular standards were examined by our methods but the data obtained in such instances have been treated separately.

To obtain as reliable and as complete an appraisal as was possible it was decided to examine each patient twice prior to operation and at 2 different intervals postoperatively. Our schedule was as follows:

Preoperative	Two months prior to operation, (-60A)
	Two weeks prior to operation, (-14B)
Postoperative	One week after operation, (+7C)
	Three months after operation, (+90D)

The repeated measure prior to operation was added insurance that an adequate appraisal had been made of any particular patient and the follow-up covering a 3-month period thereafter was designed to reflect the temporary or permanent nature of any alteration which might be detected.

Of all operated cases we found 9 who were able to give adequate performance at most testing periods and on most of the varied tests contained in this battery. Generally we have considered all of their data in the evaluation of operative effect. More specifically, however, we were inclined to accept the data from our best 6 cases as a better basis for our final conclusions. Because of the tedious quality of the various tests and their susceptibility to interference by psychotic process we believed it to be a necessity to accept for consideration only the very best cases if our conclusions were to be valid. We considered B3, B5, B6, B8, B10A, and A8 our best 6 subjects. Fragmentary, but usable data were obtained from B11, B15, B16, and B21.

The cases receiving the VL operation were numerous enough to be considered in group fashion. Although no elaborate statistical treatment was feasible in view of the small number of cases, their data were found to be sufficiently comparable to be handled as a small group for purposes of comparing pre- and postoperative averages.

Since some of the operations were performed on 2 patients only, it was impossible to consider them as an operative group and they had to be evaluated from such data as were available on individual patients. Since our data had been strongly limited by the factors noted previously we did not possess complete coverage of all cases. All of the operative techniques, except thalamotomy was represented to some extent in our data. Quite obviously opportunity was limited to observe the possible effects of those operations performed on only 2 patients. For 2 of the operations, however (VL and TO), a larger number of patients was available. Unfortunately, only one case out of the 9 available of transorbital lobotomy met the necessary criteria for inclusion in this study. The venous ligation patients were better represented and data were available on 5 patients receiving this operation.

RESULTS: VENOUS LIGATION PATIENTS

VISUAL ACUITY. On the basis of examination by Snellen chart we were unable to detect any alteration of visual acuity resulting from this operation. The measures afforded by the test showed some degree of unreliability but none which could be meaningfully interpreted as a change in visual acuity.

PERIPHERAL VISUAL FIELD. All of the subjects included in this study were found to have normal peripheral visual fields prior to operation, and in no instance was any alteration apparent postoperatively.

CRITICAL FLICKER FREQUENCY, STROBOSCOPIC. The mean CFF obtained by this method at -60A was 37.1, at -14B was 38.1 and at +7C was 39.4 and at +90D was 39.8. There is apparent a slight increase from one testing period to another throughout the measure, but the magnitude of change when ranged against the variability of this population is not a significant one.

Table 48

CRITICAL FLICKER FREQUENCY (STROBOSCOPIC) MEANS AND STANDARD DEVIATIONS IN THE VL PATIENTS STUDIED (IN CYCLES PER SECOND)

	Testing Period			
	-60A	-14B	+7C	+90D
Mean	37.1	38.1	39.4	39.8
SD	3.80	2.58	1.85	2.69

CRITICAL FLICKER FREQUENCY, EPISCOTISTERIC. Thresholds obtained by this method, the means of which are shown in Table 49, show little change. Some fluctuation is present in the measures at the various levels, but these are not great enough to be meaningful in terms of the observed variability.

Table 49

CRITICAL FLICKER FREQUENCY (EPISCOTISTERIC) MEANS AND STANDARD DEVIATIONS FOR THE VL PATIENTS STUDIED (IN CYCLES PER SECOND)

	Testing Period			
	-60A	-14B	+7C	+90D
Level I				
Mean	10.9	9.5	9.6	9.2
SD	1.14	0.92	0.69	1.69
Level II				
Mean	17.0	14.1	15.1	15.0
SD	0.81	1.50	2.10	1.73
Level III				
Mean	20.0	19.1	17.3	19.1
SD	1.00	2.98	2.82	1.73

VISUAL INTENSITY DISCRIMINATION. Results obtained in the test of intensity discrimination are presented in Table 50. Our original choice of stimulus intensity for Level I was too dim so that most of the patients could not perform the task. Hence it had to be made brighter at the next testing period and we must rely on but one preoperative measure. It is apparent that there was a steady decrease in degrees of arc necessary to establish one JND for each level of illumination as we went from -14B to +7C and +90D testing periods. This finding would make it appear that discrimination was being made in an increasingly efficient manner. Some question had been raised, however, in the administration of this test as to what appeared to be relatively large practice effects in such a group of patients. Since it was not possible to ascertain whether this was the case or whether there was a genuine alteration of the function on the basis of these data alone the performance of a comparable group of psychotics on the same test prior to operation was examined. A large practice effect was visible and whereas this related observation does not suffice to discount the decreasing trend seen in the present data it brings into question speculations upon the actual alteration of the function. The situation is not clearly defined with the present data, and further study under more controlled conditions will be necessary to establish the facts.

Table 50

VISUAL INTENSITY DISCRIMINATION AVERAGES FOR THE VL PATIENTS STUDIED (REPRESENTED AS DEGREES OF ROTATION OF THE POLAROID)

	Testing Period		
	14B	*+7C*	*+90D*
Level I	24.2	20.1	16.9
Level II	26 9	22.3	20.7
Level III	37.3	33.0	28.1

SPACED PERCEPTION. The average separation of 2 stimulus elements which could be perceived regularly with an exposure of 150 milliseconds at -60A was 29.7 mm, at -14B it was 36.3 mm, at +7C it was 31.0 mm, and at +90D it was 35.0 mm. Some improvement in performance between the first and second preoperative measures was apparent, but immediately following operation some reduction in this function can be seen. Since the retest at +90D again shows improvement in performance, the change that takes place represents a temporary loss of efficiency.

PERCEPTION TIME. Measures of the length of time required for the patients to perceive standard stimuli correctly showed considerable variation in performance between individuals. No consistent trend was observable in the data obtained on the VL cases and no evidence gained which would indicate any alteration of this function.

AUDITORY ACUITY. Sufficient audiograms were plotted preoperatively to yield a satisfactory estimate of the status of pure tone thresholds for each patient. None of the cases showed an appreciable hearing defect preoperatively, with the exception of some expected high frequency loss in the older patients. A tabulation of the determined thresholds for the 4 testing periods showed only expected variation in the repeated measures for frequencies of 64, 128, 256, 512, 1024, 2048, 4096, 8192 cps. It will be recalled that an additional tone of 13,000 cps was added to our audiometer, since statements have been made in the literature that brain operations decrease the auditory acuity at the higher tonal levels. Measures made with this tone, using the 8192 cps scale as a reference point, yielded average values in terms of decibels of hearing loss of 42 at -60A, 35 at -14B, and 44 at +7C but at +90D only one patient (B3) could hear this tone at all at a value of 45. (Five db lower than her preoperative threshold.)

It seems fair to conclude that venous ligation was attended by no loss in auditory efficiency within the range of ordinary hearing, that is between 64 and 8192 cps. Although our data are not complete nor entirely satisfactory they do indicate a possible decrease or loss in hearing at 13,000 cps following venous ligation.

PAIN THRESHOLD. Regular pain thresholds were not easily obtained with these psychotic patients because of the introspective nature of the measure and the difficulties of maintaining standardized instrumentation in the clinical situation. For this reason the average thresholds shown in Table 51 were accompanied by rather large standard deviations for these measures.

Table 51

MEAN PAIN THRESHOLDS AND THEIR STANDARD DEVIATIONS FOR THE VL PATIENTS STUDIED (IN MILLICALORIES PER SECOND PER SQUARE CENTIMETER)

	Testing Periods		
	-14B	+7C	+90D
Mean	241	241	256
SD	11.9	43.2	20.5

Although differences occur between the average thresholds these are not significant in terms of the large standard deviations obtained.

RESPONSE TIME. The average time that it took the venous ligation patients to respond to a buzzer and to a light at each of the 4 testing periods is given in Table 52.

Table 52

MEANS AND STANDARD DEVIATIONS FOR RESPONSE TIME TO SOUND AND TO LIGHT FOR THE VL PATIENTS STUDIED (IN HUNDREDTHS OF A SECOND)

	Testing Period			
	-60A	-14B	+7C	+90D
Sound				
Mean	62.8	62.4	74.8	62.4
SD	12.3	12.0	9.0	13.1
Light				
Mean	63.4	68.2	79.2	66.6
SD	11 4	15.0	8.9	11.3

Both sound and light responses were seen to be very similar preoperatively and in close agreement between test periods. Following operation both were increased to about the same extent and then on later retest both were seen to have returned to the preoperative level. Although the change in score was not significant in terms of the variability of the measures, the correspondence between the 2 measures and the consistency of performance throughout the group was impressive. Each individual showed this temporary loss in speed of response for reaction to light and to sound signals.

TAPPING. Mean scores on this test of the speed of repetitive movement during a 5-second interval are shown in Table 53.

Comparison of these scores indicates a slight loss immediately following operation seen as a loss in practice effects. The change is not a significant one in terms of the variability of the measures, but is consistent for all patients and is in agreement with the similar trend noted in Response Time.

FINGER DEXTERITY. This test requires the dexterous use of the fingers in making fine movements. It affords measures for the right hand, left hand, both hands and an assembly performance in which the

Table 53

TAPPING TEST MEANS SCORES AND THEIR STANDARD DEVIATIONS FOR THE VL PATIENTS STUDIED (5-SECOND INTERVALS)

	Testing Period			
	-60A	-14B	+7C	+90D
Mean	14.7	16.2	14.3	16.7
SD	1.96	1.73	1.53	2.51

2 hands are used in a coordinated fashion. Table 54 presents the mean values for the combined (right plus left plus both hands) and for the assembly scores.

Table 54

MEAN FINGER DEXTERITY SCORES AND THEIR STANDARD DEVIATIONS FOR THE VL PATIENTS STUDIED

	Testing Period			
	-60A	-14B	+7C	+90D
Sum of Right, Left, and Both Hands				
Mean	38.0	38.8	34.2	38.4
SD	2.85	4.47	3.06	3.21
Assembly				
Mean	29.2	29.4	24.8	31.0
SD	4.79	4.84	5.04	3.16

Preoperative performance seemed to be stable for each of these measures, but immediately following operation a reduction was observable in both. At the +90D retest, however, this loss had been regained and both scores were in close approximation to their preoperative level. As was noted in the results of our other motor measures, this alteration of performance immediately after operation was not significant statistically, but was impressive in terms of its consistency.

Summary of Findings with the Venous Ligation Patients

1. There was no alteration in visual acuity or in the peripheral visual fields which could be related to the effects of venous ligation.

2. Determination of CFF by stroboscopic and episcotisteric methods did not indicate that any alteration of threshold results from the venous ligation operative procedure. Some fluctuation in the measures was present but was not great enough to be meaningful in terms of the observed variability.

3. The visual intensity discrimination measure did not produce completely adequate data, but we do not believe that it reflects major alteration by the venous ligation.

4. There was a temporary loss in the efficiency with which the spaced attention task could be done. There was a transient change, probably in the ability to maintain a high level of attention.

5. There was no alteration, either transient or permanent in perception time.

6. There was no regular alteration in the audiogram between 64 and 8192 cps following operation. There was evidence of a loss in the 13,000 cps threshold determination. Our data to this last point were indicative but not wholly satisfactory.

7. Our data indicated that venous ligation did not significantly alter the pain threshold at either of the postoperative test periods.

8. Response time was increased in a transient fashion 10 days after operation and returned to its preoperative level 3 months postoperatively.

9. There was a slight loss in the speed of tapping 10 days after operation.

10. Finger dexterity showed the same transient loss in efficiency 10 days after operation with a return to its original level 3 months postoperatively.

11. In general sensory functions were unaffected, while motor tasks showed a transient loss in efficiency.

RESULTS: OTHER VARIETIES OF BRAIN OPERATIONS

As pointed out earlier in this chapter we did obtain relevant data on 2 patients who underwent frontal lobe thermocoagulation (TC) (B15; B16), on one transorbital lobotomy patient (TO) (B21), and on one patient (A8) with a topectomy enlargement (ET). The ET case yielded reliable data useful in evaluating the effect of this type of surgery. The 2 TC cases and the one TO, however, did not give trustworthy data by reason of strong distractibility, disorganization, and mood shifting. Because they are the only representatives of the surgical techniques of TC and TO they merit some consideration, but it is to be understood that qualification of their performance is necessary.

Table 55 has been constructed to illustrate the relation of postoperative performance to preoperative level. We have entered in this table symbols indicating relative performance in which 0 indicates no change, + indicates an increased efficiency, and - indicates a decreased efficiency. These symbols indicate tendencies, not clearly marked alterations of performance. As a guide in making these evaluations we have employed a symbol of change whenever the individual patient exceeded one standard deviation obtained with the VL group.

Table 55

PATTERN ANALYSIS* OF THE PERFORMANCE OF 4 INDIVIDUAL PATIENTS WITH TC, ET, AND TO OPERATIONS

PATIENT NUMBER	A8		B15		B16		B21	
Operation	ET		TC		TC		TO	
Test Periods Compared	B:C	B:D	B:C	B:D	B:C	B:D	B:C	B:D
Visual Acuity	0	0	0	0	0	0	0	0
Visual Fields	0	0	0	0	0	0	0	0
CFF	0	0	0	0	0	0	0	0
Percept. Time	0	0	0	0	0	0	0	+
Audiometry	0	0	0	0			0	0
Hi. Tone Acuity	0	0	0				0	-
Spac. Percept.	-	0	-	0	0	0	-	0
Pain Thresh.	-	0	0	0	0	0	-	0
Tapping	+	+	0	0	0	+	0	+
Response Time	0	0	0	0	0	+	0	+
Finger Dext.	-	+			0	+	0	+

*0 means no change
+ means increased efficiency
- means decreased efficiency

Inspection of this table provides us with the following conclusions:

1. The measures of Visual Acuity, Peripheral Visual Fields, CFF, Perception Time, and Audiometry showed no essential change in these functions in any of the individual cases.

2. Measures of Spaced Perception indicated a temporary loss in efficiency immediately following operation in 3 of the 4 cases (A8, ET; B15, TC; B21, TO).

3. Pain Thresholds were slightly reduced in 2 patients (A8, ET; and B21, TO) but remained at preoperative level for the remaining 2 cases (B15, TC; and B16, TC).

4. The 3 motor measures of Tapping, Response Time, and Finger Dexterity reflected no loss immediately following operation and, in fact, showed some gain in performance at the +90D test period.

DISCUSSION

In the literature on the human frontal lobes one finds little or no mention of sensory function or convincing evidence that frontal lobe damage has repercussions in the sensory sphere. Certainly from what is known at the present time of the localization of sensory function (Fulton, '43) in the human brain one would not expect to find any marked interference to result from frontal damage.

In thinking about the results which we obtained it must be borne in mind that performance on these tests was somewhat more variable for those psychotic patients than is the case when they are applied to normal subjects. Nevertheless the data obtained were generally stable and any changes that took place are not to be attributed in any major way to practice on the test-to-test variability. The relative precision of these measures, compared to most psychologic tests, leads us to believe that an appreciable alteration of sensory or motor function resulting from frontal lobe surgery would not fail to be reflected in these measures.

Only 2 possible changes in sensory functions were indicated by our data. These appeared to be reduction in the patient's ability to maintain active attention to 2 stimulus sources presented to him simultaneously. Also there seemed to be some loss in acuity for the highest total frequency (13,000 cps) which became manifest only at the later testing period. The remainder of the sensory tests were in no way altered and it would appear on overall evaluation that the sensory functions were not influenced by known damage to the frontal lobes. Such changes as were observed may be attributable to the general debilitating effect of surgery, to cerebral edema or to a temporary period of compensatory function. It is difficult to understand, however, why any of these should result in a condition of no alteration for most of our sensory measures but rather consistently interfered with Space Perception and High Tone Acuity. These trends in the data, and they are only trends, are not sufficiently clear to merit excessive theorizing at this time. They must certainly, however, be followed up in future series of frontal cases if their existence is to be established and any connecting link between the 2 is to be ascertained.

Previous investigations have demonstrated certain motor effects to result from damage to the posterior part of the frontal lobe but these effects have not been observed to accompany damage to the more anterior frontal association areas (Fulton, '38).

In order to obtain representative measures of our patients' motor performance we have selected 3 tests, chosen from the many available, which measure rather unrelated aspects of motor function. These have been selected from a background of knowledge of the components of motor function gained from industrial personnel selection and this assumption has been borne out by non-significant coefficients of correlation obtained when scores made preoperatively were interrelated.

The results obtained with the patients in the VL group have demonstrated a reduction of motor speed immediately following operation on these 3 motor tests. By the +90D testing period these losses had been completely regained.

The other operated cases, generally speaking, showed no such temporary impairment in performance, and by the 3-month testing period had actually shown increases in their motor speed.

The clear discrepancy between the performance of patients in the VL group and the other operated cases may be due to the fact that the VL operation is more extensive with possible infringement upon some portion of the motor area. Another possible explanation is that the VL operation, being most severe, showed the greatest effects in behavior, whereas the other operations, of lesser severity, showed only slight effects in behavior by diminishing expected improvement through practice. The existing data are entirely too fragmentary for speculation on this point, but future experimentation may be expected to clarify such a possible relation between severity of operation and the amount of motor impairment.

It is interesting to note that we failed to find any clear tendency toward a raised pain threshold following these frontal lobe operations although the relief from intractable pain due to cancer, spinal cord tumors, etc., following either unilateral or bilateral frontal lobotomy has been repeatedly found.

Investigation of the function of critical flicker frequency in frontal lobe cases has been reported by Halstead ('47) and by Young ('49). Utilizing a stroboscopic stimulus source Halstead found the CFF to be significantly low on postoperative examination when compared to the thresholds of normal subjects. With a similar technique applied both pre- and postoperatively Young reported no mean change in threshold to occur in a group of 17 topectomy cases, but reported that 9 of her 17 cases showed some decrease in CFF following operation and that 6 of these 9 made a social recovery from psychosis. These 6 cases all had a high preoperative CFF.

In view of these findings we have made a particular effort to obtain adequate measures of this function pre- and postoperatively employing the 2 methods and various levels of the function previously described. Our cases exhibited remarkably stable performance on these

tasks with no indication of an alteration in the mean thresholds obtained. Only one of our cases had a sufficiently high preoperative CFF to be comparable with Young's 6 cases. This high CFF was somewhat reduced after operation, but no improvement was noted in the psychotic condition of this patient.

Since relatively few of the operated patients were classified as acceptable cases for this study we have utilized the entire battery again for the examination of patients in a current series. This will provide sufficient data for the formation of more general conclusions. The tendency towards change recorded for Spaced Perception and High Tone Acuity certainly require additional cases before one can be certain of the events taking place. Furthermore, it would be of importance to verify the changes in motor functions on cases of less extensive frontal lobe damage than venous ligation, and to observe generally the effects on motor function of frontal lobe operations.

SUMMARY AND CONCLUSIONS

1. A number of psychophysiologic tests exploring visual, auditory, somesthetic-kinesthetic and motor functions have been applied pre- and postoperatively to a group of psychotic patients undergoing frontal lobe surgery.

2. No general alteration of sensory function was observed; however, some tendency toward reduced function was noted in the tests of Spaced Perception and High Tone Acuity.

3. Motor function was observed to be reduced immediately following operation in patients receiving the venous ligation operation. No such loss was apparent for the other operated patients, including topectomy enlargement, thermocoagulation and transorbital lobotomy.

4. The findings have been discussed with reference to related observations on sensori-motor aspects of the frontal lobes.

Chapter 14

DISCUSSION OF PSYCHOLOGIC INVESTIGATIONS

Carney Landis and Joseph Zubin

In summarizing the psychologic changes following topectomy Landis ('49) commented as follows: "No patient in this group of 19 operatees which we have studied had a real or permanent impairment of mental function brought about by the operation, which could be demonstrated in any way by our exhaustive psychological test battery. In individual patients specific losses in the form of marked decreases in scores did occur but these losses were, so far as we could tell, more than compensated for by other marked gains and hence did not lead to impairment. There was no real loss in memory, learning, or intellectual functions brought about by any of the topectomy operations. There was a real valid gain in some recall and recognition memory scores in many of the patients, which gain was usually associated with the social recovery of the patient."

In the first Columbia-Greystone project a certain number of the topectomy patients made a "social" recovery from psychoses. The psychologists had difficulty in trying to decide how much of the change in psychologic test performance was due to recovery from psychosis and how much might be attributed to the operation itself. A second difficulty in the first project grew out of the fact that 23 of the patients were subjected to topectomy (an excision of tissue) and one to a venous ligation (no excision of tissue). The psychologic changes which occurred in the one venous ligation patient were just as clear and distinct as those which took place following any variety of topectomy operation. In the interpretation of the findings the facts of recovery from psychosis and an operation without removal of tissue complicated all attempts at explanation.

In the present study we have been able to clarify the psychologic findings on both of these points. (1) No patient made a recovery from psychosis following this series of brain operations prior to the completion of the psychologic tests. (2) In the present series different kinds of surgical techniques were employed, most of them non-specific in character. The venous ligation, thalamotomy, and transorbital operations were all of such a nature that it would have been unwarranted to believe that anything like the same specific areas of brain tissue were involved. Hence, any changes which were found running through the entire series of patients must be attributed to the generality of function of frontal lobe tissue, unless such changes could be

shown to be clearly differential in one or several patients without occurring in any other patients.

We should also point out that most of the psychologic procedures which were used in this set of investigations were new but were for the most part derived from ideas which had arisen from the experience gained from the first Columbia-Greystone project. Some of the methods used were precise and well standardized; others lacked precision, and still others had neither standardization nor precision. However, they were all of such a nature that they might conceivably have clarified certain of the questions which the first Greystone project brought into the foreground.

At the risk of being repetitious we feel that it is wise to bring together again in a summary fashion the outstanding conclusions which were found and which have been reported in chapters dealing with the psychologic portion of this investigation.

1. The Wechsler-Bellevue scale of Adult Intelligence showed no general permanent loss which could be attributed to any of these surgical procedures. The rate of improvement on the scores made on the performance portion of the test showed a greater deficit among the operated patients than it did among the control group. This deficit was most clearly shown by those individuals who received the more severe venous ligation operation (VL-I). There was a significant loss in scores on the subtests of Picture Arrangement, and Object Assembly which had not been fully regained 6 months after operation.

2. The Porteus Maze test showed an immediate drop after operation with a full recovery in all but the thalamotomy patients by 3 months after the operation. The gains which were attributed to practice or learning and which were made by the operated patients were not as great as those made by the control patients during the same period.

3. The Weigl test was not consistently changed in its performance following operation. There was more loss shown by the operated patients in their ability to verbalize their performance on this test after operation. This loss in ability was attributed to a decrease in "motivation."

4. The Revised Homograph test showed a clear loss in all patients 10 days after operation with a full resumption of function in most patients 3 months after operation. The postoperative loss seemed to be due to a lack of motivation to try to think of more than one or 2 definitions for the common words of the test. It was as if more effort was required to find the familiar words and the effort led on occasion to "compensation" by using unfamiliar words or phrases. Three months after operation these patients were able to use the same defining words which they had used before the operation, that is there was a "resumption of function" rather than a continuation of compensation.

5. There was no evidence of loss or change in either Incidental or Direct Memory which could be attributed to any of these brain operations.

6. There was no loss or change in ability to do the Delayed Reaction experiment which could be attributed to any one of these operations.

7. In the Verbal Directions experiment, the 4 control patients showed some learning effect on Form A pretest to posttest. Not so much learning effect was shown by the operatees. On Form B neither group showed any learning effect.

8. On the Learning test there was no evidence for an intraserial effect. There was evidence that the "forced" method of learning was more difficult for the operatees immediately after operation than the "free" method of learning. On the Interrupted Set experiment the operated did not do quite as well immediately after operation as did the controls. There was no consistent loss or change in the Sustained Task experiment.

9. The Attitude Evaluation indicated that the outlook on life and the problems of life of these particular patients were reported with a great deal of reliability and consistency and that little or no change was brought about by these brain operations.

10. There was some amnesia on the part of 6 of the operated patients for the last preoperative week and for the circumstances surrounding the operation itself.

11. There was little or no evidence of any interference with visual, auditory, or pain sensitivity so far as the primary sensory functions were concerned.

12. There was evidence of an interference 10 days postoperatively on the Spaced Attention test, on the Tapping test, on the Response Time test, and on the Finger Dexterity test.

13. The Time-Sampling observation study showed certain variations but there was no evidence that these variations with the A or S series could be attributed to the operations.

In the light of these findings certain conclusions seem clear and obvious. First, there can be no doubt that there is no general permanent loss of intellectual function, memory, ability to learn, intelligence, or the like which could be attributed to any of these surgical procedures which were carried out on the frontal lobes. Second, there is rather consistent evidence that there was a transient loss for the 2 or 3 weeks following operation, in the efficiency with which certain functions were performed.

In Chapters 9 to 13 inclusive, a variety of attempts at explanation of the basic nature of this transient loss have been made. Among these tentative explanations have been lowered interest or motivation, lowered ability to learn or to benefit from practice, and a lowering of basic capacity. Although any one of these tentative explanations might hold for the particular task or experiment involved it is difficult to explain all of the varieties of transient loss in any of these terms.

This transient loss usually exhibited itself in the following way. The patient seemed more lackadaisical, more easy going, and less

highly motivated toward the task at hand. If he was sufficiently stimulated it was often possible to get him to give as good a performance as he had given preoperatively, although as a usual thing it could not be done quite as rapidly as it was preoperatively. It was as if the individual was under an interfering influence, which interference resulted in a lack of drive or energy to complete the task as rapidly or as successfully as had been done at the preoperative test periods, or as would be done 3 months after the operation. Again it was as if the patient were sleepy, fatigued, or partially drunk so that there was disinclination to work at his usual level. It seemed at times as though there was a defect in the self-criticism necessary to produce the "normal" performance. It was usually possible by prompting, urging, or repetition to obtain as good a measure as had been obtained preoperatively, but it took an increase in stimulation to get such results. The transient deficit showed itself most clearly in motor or verbal tasks which require some "effort" or "attention," for example: free versus forced learning.

There is no certain evidence as to the basic cause of this interference or disinclination. Our evidence could be produced by either or both physiologic and psychologic factors. The Attitude Evaluation Interviews showed no basic psychologic changes in expressed motivation, while the evidence from the physiologic and laboratory tests is equally unrevealing.

In contrasting the psychologic finding of the present study with those of the first project, it is apparent that the changes due to recovery from psychosis are mainly, if not entirely in the realm of affective attitudes, loss of anxiety, decrease in complaints and the like. These affective attitudes probably interfere with the quality and quantity of performance in most of the psychologic tests that have been employed in both this and the previous study but that interference has affected the operated and control groups alike.

In conclusion, it is our present opinion that the psychologic changes which have been reported in both the clinical and experimental literature to be attendant on frontal lobe damage have been drawn from the study of too few cases and from the study of cases too soon after operation. If measurements are obtained in which preoperative levels were carefully established and sufficient time is given for recovery from the operation then no present evidence exists that "clean" and uncomplicated operative procedures done on the frontal lobes produce any permanent change in psychologic ability, capacity, or basic efficiency. It may be that more extensive damage that has resulted from any of the surgical techniques used in either Columbia-Greystone project or damage which is complicated by involving other than the frontal lobes will produce losses. We have no evidence on this last point. Finally we have no evidence that any function which we investigated is related in a specific fashion to any particular frontal lobe area, rather there was a generalized transient performance deficiency which is brought about by any sort of frontal lobe surgery.

Chapter 15

REPORT OF THE PSYCHIATRIC DISCIPLINE

Paul H. Hoch, James P. Cattell, Harry H. Pennes

INTRODUCTION. The psychiatric discipline was responsible for picking patient candidates for the project, from a previously selected pool, according to criteria agreed upon by all disciplines. After selection we studied each patient carefully in order to determine diagnosis, presence and degree of deterioration, oscillations of clinical manifestations, and response to the project ward where patients were subjected to a modified "total push" regime. Our goal was to familiarize ourselves sufficiently with the vicissitudes of each patient's clinical course so that we would be able to evaluate later changes with reasonable accuracy. Following operation, patients were seen frequently during the early postoperative period and less frequently after the first 3 months.

METHODOLOGY

The patients at Greystone Park State Hospital were selected for the operations on the basis of the following criteria:

1. Diagnostic categories:
   (a) Patients with schizophrenia (paranoid type) between the ages of 45 and 55.
   (b) Schizophrenic patients (hebephrenic and catatonic types) between the ages of 25 and 35.
2. Patients were to be free of obvious evidence of medical complications or of organic brain disease.
3. Family history of functional psychosis in the direct or collateral line of the patient was reason for rejection.
4. Patients were to be reasonably cooperative for testing. Mute patients and excessively disturbed individuals were excluded as being unsatisfactory for testing by the non-psychiatric disciplines.
5. Patients with a history of gross psychopathic traits or who were involved in antisocial acts were to be excluded.
6. Patients must have been residents of the hospital for at least 3 years without evidence of remission of the mental disorder to the extent of being placed on convalescent status.

7. Patients must have graduated from an American high school.
8. A satisfactory home environment was to be available to which patients could return if discharged.

Patients with 3 consecutive years' hospitalization were preferred, but those with 3 years' illness without true remission could be included even though they had not been continuously hospitalized during this period.

Unfortunately the education and family history criteria eliminated so many patients that it became necessary to apply these requirements less stringently. Therefore, in addition to the patients who were high school graduates, those with eighth grade education were accepted. Before the selection of the patients started, it was also felt that the best case material would be that on non-deteriorated patients. However, we accepted many markedly regressed or deteriorated patients for operation because those patients who spend 3 or more years in a state hospital suffering from schizophrenia are usually not free from symptoms indicating deterioration.

After the records were reviewed, patients were interviewed by one of us, but they were not accepted until seen and discussed by the 3 of us acting as a board. (At this juncture, patients were screened by medical and psychologic disciplines.) Mental examinations were then completed and each patient again appeared before the psychiatric board. At that time, diagnostic and prognostic considerations were discussed.

Interviews with and without intravenous Sodium Amytal were held with each patient and recorded by "Soundscriber." The Amytal was used in an effort to "normalize" the patient with the hope of establishing a correlation between Amytal response and response to brain surgery. *The prototype of "normalization" is the response of the mute, rigid,* catatonic patient who refuses food. With intravenous Amytal, he relaxes, talks, eats, and is "cured" for an hour or 2.

During the interval prior to operation, the patients were seen on many occasions by one or all of us to facilitate greater familiarity with each patient, his illness, oscillations in clinical course, and to note changes associated with the regime on the project wards. For this project the nurses were supplied with an outline, not unlike the mental examination form of the New York State Psychiatric Institute covering the various aspects of behavior. They were asked to describe, rather than interpret, the patients' behavior. They were encouraged to make as many observations as possible of each patient, stressing aberrant behavior, changes in behavior, and to avoid check-list techniques of recording.

The charge nurse, who frequently saw the patients with us, was asked to comment on each one periodically both pre- and postoperatively. Her comments were independent of ours and were recorded verbatim by us or by soundscriber.

In addition, a list of 20 symptoms was used which Rose and Solomon

('48) found to change the most following lobotomy. Patients were rated periodically pre- and postoperatively by us and by the charge nurse independently as we saw the patients together.

We have seen each patient many times since operation both individually and as a board. Our comments are a summary of board findings of the course and present status of the patients. Abstracts of each case follow the body of this report.

MATERIAL

From the original pool of 94 patients, 30 remained after screening by all disciplines and permission for operation was granted for 24 of these. A control patient from the first project (A10), a topectomy operatee from the first project (A8), and a lobotomy failure from Marlboro State Hospital (MSH) were added to the group by the coordinator. Omitting the 2 reoperated patients, who will be described in detail below, there were 31 patients. Originally the older age group, 44-55, was to be made up of patients with involutional or manic-depressive psychoses. There were only a few such patients in the original pool and following screening and evaluation we felt that these were paranoid schizophrenics. Of the 25 patients for initial operation, all were schizophrenic (fig. 6): hebephrenic—16, catatonic—5, paranoid—4. Of the 6 controls, there were 3 paranoids, 1 catatonic, and 2 hebephrenics. Operatees: Male—7, female—18. Controls: Male—2, female—4. Age range: Operatees: 26-52; Controls: 28-52. Length of illness (fig. 7): Operatees: 38 to 204 months. Controls: 42 to 126 months. Duration of hospitalization: Operatees, 20-198; Controls, 26-118. Previous ECT, Metrazol, or Insulin Coma Therapy: Operatees, 16; Controls, 3.

PROGNOSTIC RATING SCALE

A "prognostic" rating was given to each patient. This was based primarily on *evidence of severe regression or deterioration* as well as on the anticipated response to classical lobotomy, the only well-established psychosurgical procedure. Four categories were used:

1. Deterioration absent. There is moderate domination by delusions and hallucinations with an emotional response appropriate to their content. With lobotomy we expect a diminished or absent reaction to delusions and hallucinations and acceptable social behavior.

2. Mild emotional and intellectual deterioration present. The patient is dominated by delusions and hallucinations with an emotional response reasonably appropriate to their content. With lobotomy we expect less domination by delusions and hallucinations and reduction of aggressiveness with approved social behavior.

3. Moderate emotional and intellectual deterioration present. The patient is markedly dominated by delusions and hallucinations, and

with inappropriate emotional response to the content. With lobotomy we expect a diminution of preoccupations with delusions and hallucinations but no change in deterioration, self-absorption, and inappropriateness.

4. Marked intellectual and emotional deterioration present. Fragmentation of personality. Essentially no change expected with lobotomy.

IMPROVEMENT RATING SCALE

The improvement of the patients was judged by the following scale: 1. Recovered; 2. Much improved; 3. Improved; 4. Slightly improved; 5. Unimproved; 6. Worse.

These ratings (fig. 54) are based on normal clinical psychiatric criteria including attitude and general behavior of the patient on the ward; attitude and behavior during interview; stream of mental activity; emotional reactions; mental trend and content of thought as well as sensorium, mental grasp and capacity, insight and judgment.

The improvement ratings given represent comparison of the status of patients on the usual hospital wards pre- and postoperatively, the project ward having been closed in January, 1949. The rating represents any change we have noted and includes independently recorded observations by the 3 of us. In the majority of cases, we agree. Disagreement involves rating a patient 4 vs. 5, or 5 vs. 6.

It must be stressed that no therapy is of striking value unless it is able to produce improvement ratings 1 or 2 which means recovered or much improved. A rating of 3, improved, designates perceptible change in the patient's psychiatric status, but much of the clinical symptomatology remains unchanged; 4—slightly improved category includes those who are somewhat better. These improvements, however, are usually within the range of oscillatory changes in the patient's sickness and occur quite often temporarily in patients who otherwise remain very sick. At times these patients are somewhat more tractable, in better contact, more outgoing, and somewhat less dominated by delusions and hallucinations. A shift to category 5 or 3 is possible as time goes on. It is obvious that not much disagreement exists in judging a patient 1, 2, or 3. Slight improvement, 4, however, is sometimes not easy to detect or it depends more on the subjective appraisal of the examiner than more conspicuous improvement.

PAROLABILITY

None of these patients was parolable prior to operation. The staff psychiatrists at Greystone Park State Hospital were very cooperative in providing us with a short statement as to why each patient was not paroled prior to inclusion in the project.

In our opinion, none of the surgical candidates was parolable from

IMPROVEMENT RATINGS

Patient Number	Date of Op	Operation	Dx Schizophrenia	Pre-Op Prog Rat	1-10-49	3-21-49	6-8-49	11-18-49	Preop Amytal Response	Postop Amy Response
B1	10-4-48	VEN LIG	HEB	3	5	5	4 *	4	0	0
2	"	"	CAT	2	4	4	5	5	✓	0
3	10-5-48	"	HEB	3	5	5	5	5	0	—
4	"	"	PAR	4	/	/	/	/	0	/
5	10-6-48	"	PAR	1	5	5	5	5	0	✓
6	"	"	CAT	3	5	5	5	5	✓	✓
7	10-7-48	"	HEB	2	4 +	4 *	5 *	5	✓	0
8	"	"	PAR	3	5	5	5	5	0	0
9	10-8-48	"	HEB	2	5	5	5	5	✓	✓
10a	"	"	PAR	2	4 +	4 *	4 *	5 *	0	0
11	10-11-48	"	CAT	2	5	5	5	5	0	0
12	10-12-48	"	CAT	1	5	5	5	5	0	✓
13	10-13-48	THAL	HEB	4	4	4-5	5	4	0	0
14	10-14-48	"	HEB	4	5	5	5	5	✓	0
15	10-15-48	THERMO	CAT.	2	5	5	5	5	✓	0
16	10-18-48	"	HEB.	2	5	5	5	5	✓	✓
MSH	10-19-48	TOP POST-FR LOB	HEB	•	5	5-6	5	5	0	✓
AB	10-20-48	TOP RE-OP	Pseudoneurotic	•	5	5	5	5	—	—
B17	10-28-48	TRANS LOB	HEB	4	5	4-5	5	5	✓	✓
18	"	"	HEB	3	5	5	5	5	0	0
19	"	"	HEB	4	5	5	5	5	0	0
20	"	"	HEB	3	5	4-5	5	5	0	0
21	"	"	HEB	2	5	5	5	5	✓	✓
22a	"	"	HEB	2	5	5	5	5	✓	✓
23	"	"	HEB	3	4	4	5	4	0	0
28	"	"	HEB	4	5	5	5	5	✓	✓
A10	"	"	HEB	4	4 +	5	5	5	0	0
B10		CONTROL	PAR	2	5	5	5	5	✓	✓
22		"	HEB	3	5	5	5	5	/	/
24		"	PAR	1	4	5	5	5	0	/
25		"	CAT	1	4 +	4 +	4 *	3 *	0	/
26		"	PAR	2	5	5	5	5	N	/
27		"	HEB	2	5	5	5	5	✓	/

VEN LIG — VENOUS LIGATION
THAL — THALAMOTOMY
THERMO — THERMOCOAGULATION
TOP POST-FR LOB — TOPECTOMY POST-FRONTAL LOBOTOMY
TOP RE-OP — TOPECTOMY RE-OPERATED
TRANS LOB — TRANS-ORBITAL LOBOTOMY

1 — RECOVERED
2 — MUCH IMPROVED
3 — IMPROVED
4 — SLIGHTLY IMPROVED
5 — UNIMPROVED
6 — WORSE

* — ON PAROLE
+ — RECOMMENDED FOR PAROLE
• — NO PROGNOSTIC RATING DEVELOPED

AMYTAL RESPONSE
0 — NO SIGNIFICANT RESPONSE
✓ — SOME RELAXATION & LOOSENING OF CONTENT
N — NORMALIZATION
— — INCREASE IN PSYCHOTIC RESPONSE
/ — NO DATA

FIG. 54. Improvement ratings and Amytal interview data.

the project ward just prior to operation though there was some increased socialization in response to this more favorable environment. However, no quantitatively appreciable improvement occurred. In June, 1949 some of the patients had been placed on convalescent status by the parole board of Greystone Park State Hospital. This group included a patient with the rating of 5, and some with a rating of 4.

If a patient has a rating of 1 or 2, a parole from the hospital is

automatic. This relationship, however, does not necessarily exist between parolability and ratings 3 and 4. Decisions concerning parolability throughout the postoperative course were made independently using the same general criteria of improvement as noted above, plus the special criteria of the patients able to live outside of the hospital in a reasonably receptive home atmosphere.

As we have mentioned before, Sodium Amytal interviews were used as an auxiliary to the clinical appraisal of the patient. The Sodium Amytal interview was considered mainly from the point of view of normalization of the patient which in turn was evaluated for prognostic purposes. In all patients who remained unchanged or only slightly improved under Amytal the operation did not lead to improvement. In one control patient where normalization took place under Sodium Amytal, no spontaneous improvement occurred later on. Based on presented case material we conclude that if a deteriorated patient did not show any remission of his symptoms under Sodium Amytal there is little prospect that the operative procedures of this study would improve his condition. It has to be kept in mind, however, that with the exception of transorbital lobotomy, the other procedures used in these patients were not standard procedures. Observations made on other case material on which topectomies were performed will indicate that the Sodium Amytal normalization test is a very good indicator as to what extent the operation will help the patient.[10] If the patient does not improve with Sodium Amytal he usually shows none or very little improvement after this operation. Normalization under Amytal, however, does not reliably predict the postoperative improvement.

RESULTS

VENOUS LIGATION. In this group of 12 patients, there were 2 men and 10 women with age range from 26 to 52. Duration of illness was 38 to 148 months. All were given a diagnosis of schizophrenia with 4 in each subcategory: catatonic, hebephrenic, and paranoid. Prognostic ratings as described above were as follows: 1, 2, 2, 3 in the catatonic group; 2, 2, 3, 3 in the hebephrenic group; and 1, 2, 3, 4 in the paranoid group. Seven of these patients had received some form of shock therapy but there was no lasting or significant improvement.

Operations were performed October 4-12, 1948 (inclusive). Venous ligation was carried out (see fig. 54) in B1 through B5 and less extensively in B6 through B12. Moderate to marked evidence of neurologic changes occurred in 7. Subsequent wound infection occurred in 2 (B7, B10A).

Improvement ratings and parolability of patients at 3, 5, 8, and 13 months' postoperatively are designated in figs. 54 and 55. On January 10, 1949 when patients were considered for parole, all psychiatric

10. To be published at a later date.

EVALUATION OF PATIENTS IN PROJECT ON JANUARY 14, 1949

	IMPROVED AND PAROLABLE	IMPROVED BUT NOT PAROLABLE
INDEP PSYCH EVAL	B5 B7 B8 B10A	A10 B1 B3
PSYCH	A10 B7 B10A B25	B2 B13 B23 B24

FIG. 55. Cases considered improved as of January 14 by present authors (Psych.) and staff psychiatrists at Greystone (Indep. Psych. Eval.). It will be observed that there was agreement concerning cases B7 and B10A.

observers (fig. 55) felt a trial was warranted in 2 instances (B7 and B10A). All patients were reviewed again on March 21, 1949.

Patients were all seen in interview in June, 1949, 8 months after operation. Two had an improvement rating of 4 (B1, B10A), 9 had a rating of 5 (B2, B3, B5, B6, B7, B8, B9, B11, B12) and one (B4) was dead. The specific evidence for slight improvement in those with a rating of 4 is given in the case abstracts. Three of these patients (B1, B7, and B10A) were on parole at that time. The first (B1) had responded slightly to the enthusiastic efforts of her family, but was functioning intellectually, socially, emotionally, and domestically between the age levels 2 and 6. The second (B7) was very difficult to manage at home and was reported by her sister to be exactly as she was preoperatively. On this account she was returned to the hospital on August 10, 1949 after an unsuccessful parole period of 22 weeks. The third patient (B10A) was making a tenuous adjustment in a family-care home. She was dominated by delusions and hallucinations but was reasonably tractable if left alone and if her relatives avoided contact with her. Her illness had been characterized by exacerbations and remissions for 20 years, though she was continuously ill during the 3-year period prior to operation. The final appraisal of these patients will have to be made after more time has elapsed.

Variability of behavior and clinical picture obtained in several of these prior to operation. This was characterized chiefly by periods of excitement, aggressiveness, overactivity, and restlessness in one phase and withdrawal, seclusiveness, or relative tractability in the other. Duration, intensity, and quality of each phase varied from patient to patient and from cycle to cycle. This oscillatory behavior is quite characteristic of psychotic patients, particularly schizophrenics, and may or may not be associated with obvious environmental stimuli. The more positive phases of these cycles should not be confused with improvement. Oscillations of behavior and illness obtained in 7 preoperatively, being marked in one, moderate in 5, and mild in one. After operation these oscillations continued essentially unchanged with the following 4 exceptions: Of those with moderate oscillations before operation, there was a decrease in 3 and an increase in one.

There is no evidence of correlation between the slight improvement observed and the diagnosis, duration of illness, previous shock therapy, response to Sodium Amytal, oscillations in clinical course, plane of ligation, or presence of transient but severe neurologic signs.

THALAMOTOMY. Two male, hebephrenic patients (B13, B14) were subjected to this procedure. Age: 32 and 26. Duration of illness: 106 and 67 months. Prognostic rating: 4 in each case. Both had received insulin coma treatment, and in addition, one had Metrazol and the other, ECT. Operations were performed October 13, 1948 and October 14, 1948. Marked evidence of neurologic changes were present in both postoperatively but disappeared completely in 2 to 3 weeks. Neither had a wound infection. Details of postoperative course during the first 8 months are included in the case abstracts and in Table 56.

In June, 1949 both were in the hospital with improvement ratings of 5. They were definitely not parolable. Pre- and postoperative responses to intravenous Sodium Amytal were not impressive. Both have shown oscillations of behavior before and after operation, more marked during the latter period.

THERMOCOAGULATION. Two female patients (B15, B16) diagnosed as catatonic and hebephrenic schizophrenia. Age: Both 30. Duration of illness: 62 and 108 months. Prognostic rating: 2 in each case. The first patient had received both insulin coma and ECT but the second had neither. Operations were performed on October 15, 1948 and October 18, 1948. There were no gross neurologic signs or evidences of wound infection in either patient. By January, 1949 both patients had relapsed to the preoperative clinical picture after a transient period of seemingly better integration. Neither was a candidate for parole. Improvement rating in June, 1949: 5 in each case. Pre-and postoperative intravenous Sodium Amytal interviews revealed little of note.

TRANSORBITAL LOBOTOMY. Nine patients (B17, B18, B19, B20, B21, B22A, B23, B28, and A10) received this operation. The diagnosis was hebephrenic schizophrenia in all these patients. Three (B19, B20, and A10) were males and 6 (B17, B18, B21, B22A, B23, and B28) were females, with an age range of 27 to 45. Length of illness ranged from 57 to 240 months. Two (B21, B22A) of these patients had prognostic ratings of 2, 3 (B18, B20, and B23) had a rating of 3, and 4 (A10, B17, B19, B28) had a rating of 4. Six (B18, B19, B20, B21, B22A, and A10) received shock therapy at some time during their hospitalization without significant effect on the psychosis.

In the preoperative workup, intravenous Sodium Amytal produced no integrating effect of note and produced some relaxation and loosening in 3 (B17, B21, B22A). Preoperative oscillations on the project ward were of significance in only one patient (B21) whose behavior ranged from stilted, sterotyped compliance to explosive paranoid

Table 56

WEIGHTED SOCIAL RATINGS OF TOPECTOMIZED, UNOPERATED CONTROL AND LOBOTOMIZED CONTROL PATIENTS 7 1/2 MONTHS, 1 YEAR AND 2 YEARS AFTER OPERATION*

	Patient No.	Areas Involved											Weighted Social Rating After Operation		
		6	8	9	10	11	24	32	44	45	46	47	7 1/2 mos.	1 yr.	2 yr.
Topectomized Patients	7		x	a	a								5	5	2
	13			a	a					x	x		6	6	6
	21				x								6	6	6
	22			x	x						x		3	6	6
	25		x	x	a						x		8	8	8
	27R	a	a	a	a								7	0	0
	33				a				a	x	a		8	0	Died
	38	b	b	b									8	8	8
	42					x							5	5	5
	49				x	a					a		6	6	6
	2L	a	x										0	0	1
	3	a		a									2	0	0
	4				a						x		2	6	6
	6	a	a										1	1	1
	8R	a	a	a	a								0	0	0
	18					x							0	0	0
	19									x			0	0	7
	24	a											1	Died	---
	31			x									1	0	0
	32		a	x	a								0	0	0
	36				x	x				x	x	x	2	2	2
	40						x						0	0	1
	44L				a							x	0	0	0
	47								x				0	0	0
Unoperated Controls	9													4	0
	12													0	3
	15													5	5
	34													6	6
	39													6	6
Lobotomized Controls	5													5	5
	11													7	7
	20													6	0
	23													2	2
	28													0	0
	46													0	0
	26	Transorbital lobotomy, April 1949												0	2

*(a) Partial resection of area
(b) Venous ligation
(L) Lobotomy following unsuccessful topectomy
(R) Reoperation with extension of original removal
(x) Total resection of area

outbursts with a fixed fantasy content; this patient's variations were within the framework of her psychosis and did not represent true improvement.

All the transorbital lobotomies were performed on October 28, 1948 by Dr. Walter Freeman. On June 8, 1949, none of these patients was considered improved, the improvement ratings being 5 in all cases. One of these patients (A10) showed improvement to a 3 rating in his second postoperative month, but slipped to 4 in January, 1949, and a few weeks later reached his preoperative level which he has maintained to the present time. Intravenous Sodium Amytal again produced no normalizing effect in any of these patients. None of these patients has been paroled.

TOPECTOMY FOLLOWING PREFRONTAL LOBOTOMY. The only patient (MSH) in this group was a 21-year-old girl, hospitalized at Marlboro State Hospital since 1941. Her principal symptomatology consisted of severe anxiety, terrifying visual hallucinations, persecutory ideas with fears of physical attack, violent rages, assaultiveness, destructiveness, and swallowing of foreign bodies. Project diagnosis was schizophrenia, hebephrenic. After four unsuccessful courses of ECT between 1943 and 1947 she received a classical lateral transcranial lobotomy in September, 1947 at Marlboro State Hospital. Her unmanageable assaultive and destructive behavior continued unabated after this operation. On transfer to Greystone Park Hospital in October, 1948 she was found to be quite well preserved intellectually with some emotional inappropriateness. She was quite evasive and suspicious in her preoperative Sodium Amytal interview, revealing very little new mental content.

Bilateral frontal topectomy was performed on October 19, 1948. After a fairly severe organic syndrome lasting several weeks postoperatively, she gradually reverted to her preoperative condition. Follow-up letters from Marlboro State Hospital in March and June, 1949 stated that the patient was again dominated by her paranoid attitude, impulsive, violently assaultive, destructive, and had made a suicidal gesture. She was transferred to Trenton State Hospital in May, 1949 for more secure management. Postoperative Sodium Amytal had revealed little of significance.

EXTENSION OF FORMER TOPECTOMY. The only patient (A8) in this group was a 30-year-old male with a diagnosis of schizophrenia, pseudopsychoneurotic type. His illness was at least of 96 months' duration, with a total length of hospitalization of 56 months. Between November, 1944 and March, 1945 he received 39 insulin comas and 16 ECT's; between February and March, 1946 he received 17 ECT's all without benefit. In May, 1947 he received a bilateral topectomy with removal of parts of Brodmann's areas 8, 9, 10, and 46. After an initial improvement, he became just as anxious, irritable, hostile, suspicious, seclusive, and depressed; in addition, he developed generalized convulsive seizures.

On October 20, 1948 the site of his original topectomy was extended. After a mild organic syndrome in his first postoperative week, he gradually reverted to the same condition as before this second operation. In the interviews in March and June, 1949 in his original hospital ward, he presented exactly the same picture as before operation and stated spontaneously that he felt exactly the same as on admission to the hospital. Spontaneous seizures were still present; in addition, he had received electrical convulsive therapy because of depression. Intravenous Sodium Amytal, both pre- and postoperatively, increased his paranoid response with expression of some mild ideas of reference. He was rated as unimproved and not considered parolable.

CONTROL SUBJECTS. Six patients (B10, B22, B24, B25, B26, B27) were in this group. Diagnoses were hebephrenic schizophrenia in 2 (B22, B27), paranoid schizophrenia in 3 (B10, B24, B26), and catatonic schizophrenia in one (B25). Ages ranged from 28 to 52 years. Length of illness ranged from 42 to 126 months. Four were females (B10, B22, B24, B26) and 2 males (B25, B27). Two (B24, B25) had prognostic ratings of 1; 3 (B10, B26, B27) had prognostic ratings of 2, and one (B22) had a prognostic rating of 3. Three (B24, B25, B27) received various shock therapies without any lasting effect on the psychosis. Patients were assigned to control status when relatives failed to sign permits for operation.

None of these patients showed significant normalizing response with intravenous Sodium Amytal. Four of these subjects (B10, B22, B26, and B27) were essentially unchanged on the project ward and were returned to the routine hospital wards unchanged. One patient (B24) showed transient slight improvement to a rating of 4, consisting of better emotional contact, somewhat less aggressiveness and fairly regular working habits but she relapsed to her original condition after being transferred back to her original ward. The sixth control subject (B25) improved on the project ward to the extent of reacting somewhat less to auditory hallucinations, and increased sociability and cooperativeness. By June, 1949 he had been paroled to work on a farm; personal follow-up was unsuccessful, but his improvement rating in March, 1949 was 4 while he was still in the hospital.

Summary of Results for Entire Group

Twenty-five patients in 3 schizophrenic categories received 4 different operations. 22 of these patients are unimproved; 2 are slightly improved; one is dead, and not included in these figures. Two of the operated patients are on parole (B1, B10A). Of 2 patients receiving second operations after unsuccessful psychosurgery in 1947, both are unimproved. Of 6 control patients, 5 are unimproved, and one is slightly improved and out on parole. Of 12 patients receiving venous ligation, 9 are unimproved, 2 are slightly improved, and one is dead.

The patients receiving open thalamotomy, thermocoagulation, and transorbital lobotomy are all unimproved.

None of the symptoms in the tabulation of Solomon and Rose showed significant change in incidence or intensity in any of the diagnostic categories or in any of the operative approaches. This lack of response of individual symptoms is of course another aspect of the very low incidence of improvement in the group as a whole.

Case Summaries

PROJECT NO. B1 Schizophrenia, Hebephrenic type

A 33-year-old, single female photo finisher. Born in Spain; came to U. S. at age 5 months; attended art school in N.Y.C. for 2 years. Worked sporadically. Described as an active, imaginative, witty person who attracted others to her. She was affectionate; had artistic ability. No social engagements with men. At the age of 20 she stopped drawing. Occupational adjustment fair. At age 15 or 16 while studying art in Spain, she was moody. Returned to U. S. at age 17. Was depressed, hesitant, indecisive. Lost interest in art and lost confidence in herself. In 1941, became more depressed, withdrawn, frequently giggled, expressed odd ideas; was referential. ECT treatment ineffectual. Several suicidal attempts. Grandiose delusions. Hospitalized: 10/10/42, to present. She was seclusive, moderately untidy, restless, in need of supervision on the ward. Sullenness, suspiciousness were noted, and she was assaultive if annoyed. 30 insulin comas and 13 ECT's in 1943, without appreciable improvement. Project Psychiatric Findings: Manneristic, stereotyped, grimacing, overactive, underproductive, preoccupied, blocked, silly; probably actively hallucinating. Evasive about persecutory and grandiose delusions. Somewhat dilapidated. Prognostic Rating with Lobotomy: 3. On the project ward the pt continued quiet, withdrawn; was reasonably cooperative; not observed to be hallucinating; was frequently silly. Operation: Venous ligation, 10/4/48. At the end of the fourth postoperative week she was unchanged as compared with preoperative status. 3/21/49: Silly, grimacing, manneristic, stereotyped, evasive, vague; she laughed inappropriately when asked about voices. On the ward she was making a borderline adjustment, and plans were being made to have her go on convalescent status. 6/10/49: Pt had been home on parole 2 months, having left the hospital 4/17/49. Pt, her sister, and mother were interviewed together and individually. When the patient visited at home, according to the sister, during the Christmas season, her behavior was "impossible." When she left the hospital in April, the father and mother took her to the country. Initially she ate ravenously and continuously. Gradually she acquired some of the basic points of social behavior. In latter part of April, pt and parents went to family home in town. At home she was washing spontaneously, taking care of her room and clothes, eating much less. She required a moderate amount of supervision, particularly in doing simple household chores. There was a good deal of silly laughter. In interview the pt showed no modulation of affect, some stereotyped, manneristic behavior, some silliness, no spontaneity. Attention fluctuated. Pt seemed to vacillate between domination by inner content and responding to external situations. Some irrelevance and incoherence. Improvement rating—4. This is apparently associated with the efforts of the family rather than with the operation.

PROJECT NO. B2 Schizophrenia, Catatonic type

A 33-year-old separated female comptometer operator. Pt was always a stolid, hypersensitive, somewhat seclusive person, but learned easily and was well behaved. She had dates only with the man she married. Marital adjustment poor. Occupational adjustment good. In November, 1940, she suddenly acted oddly toward husband. Went into "coma"; complained of her muscles shrinking. Expressed other bizarre somatic ideas; thought her food was poisoned, and had auditory hallucinations. Hospitalized: 12/23/40 to present. Paroled 12/11/41 to 3/12/43. Expressed many ideas of influence and of spirits influencing her mind; had the idea her mother was dying, and continued to fear the food was poisoned. She had several visits home, but always expressed the desire to return after a few days. In the hospital laundry she worked satisfactorily, but had sporadic periods of excitement necessitating seclusion. 35 insulin comas and 14 ECT's in 1941; questionable improvement. Project Psychiatric Findings: Disorganized, incoherent, belligerent, aggressive, affectively shallow, and inappropriate with much grimacing, some manneristic behavior. Mumbled to self as if hallucinating. Prognostic Rating with Lobotomy: 2. On the project ward pt was for the most part quiet, cooperative, withdrawn, silly, but sporadically noisy and negativistic. Shortly prior to operation it appeared that she was better organized and socializing more. Operation: Venous ligation, 10/4/48. Two months postoperatively she continued to behave in interview essentially as she did preoperatively though she was less tense, more cooperative. Ward nurses reported her as less loud, better organized, less suspicious, more coherent, and much more occupied and sociable on the ward. Slightly improved. 3/21/49: Silly, affectively shallow, inadequate; much manneristic and stereotyped behavior. Pt was working in the industrial building. On the ward no change was noted in pt's condition. 6/9/49: Vacuous, shallow, superficial, manneristic, but cheerful. Bizarre ideation; much scattering. Pt said to be making fair adjustment on the ward. It was difficult to see any essential difference from her preoperative state. Improvement rating—5.

PROJECT NO. B3 Schizophrenia, Hebephrenic type

A 34-year-old, single female stenographer. Was able to obtain a position and always lived at home. Described as cheerful, sensitive, shy, seclusive, quick-tempered, stubborn, critical, overneat; never had social engagements with men. Since menarche occurred at 16, she had been observed to lock herself in her room the first 2 days of her period. In January, 1938, she became progressively more withdrawn. Exhibited grimacing and manneristic behavior. Elaborated a series of delusions about a love affair with a Spanish teacher which resulted in her being sent to Bellevue. There were many delusions and hallucinations involving this teacher. Hospitalized: 10/20/38 to present. Initially resistive, negativistic, assaultive; more recently silly, superficial, exposing self frequently, but more quiet and able to care for self. 46 insulin comas and 24 Metrazol convulsions in 1940. Unimproved. Project Psychiatric Findings: Silliness, stereotypy, fragmentation, incoherence, auditory and visual [illegible] secutory varieties. Prog- [illegible] lly, talkative, continuously [illegible] d worker and cooperative [illegible] noisy, and would beat her chest with her fists. Operation: Venous ligation, 10/5/48. During the third

week postoperatively her psychiatric condition was essentially the same as preoperatively. 1/10/49: Unimproved. Pt continued the delusional, hallucinatory pattern of essentially the same content. Was very silly, stereotyped, incoherent, and deteriorated. On the ward she was usually idle; no initiative or interest; was quite seclusive. 3/21/49: Silly, grimacing, shallow, inappropriate; whispered to self during interview. Better ward adjustment reported. 6/8/49: Pt silly, giggling, inappropriate, vacuous. Delusions and hallucinations involving the Spanish teacher, persisted. Much stereotyped use of certain phrases. Very manneristic. Condition on the ward reported as unchanged. Improvement rating—5.

PROJECT NO. B4 Schizophrenia, Paranoid type

A 50-year-old, married female domestic and waitress. Had always been friendly, fond of her children; showed good judgment, was a neat housekeeper. She was separated from her husband. Latter part of 1940, gradual onset of hypochondriacal ideas, a paranoid trend including the idea her food was poisoned by her mother, the doctors were trying to dope her; friends were throwing gas bombs on her. She was very referential. Had bizarre ideation and was openly hallucinating in the auditory sphere. Confusion and depression appeared, and she was hospitalized. Hospitalization: 1/18/41 to 2/6/42; 7/14/42 to present. 26 insulin comas, 2 Metrazol convulsions, 14 ECT's in 1941; 38 insulin comas, 14 ECT's in 1942. *No lasting improvement. In the hospital was a conscientious* dining room worker. Seclusive, tidy, and neat. There was steady deterioration. Project Psychiatric Findings: Pt cooperative, relatively pleasant, but completely incoherent and irrelevant producing a word salad. Facial expression was flat; affect was very definitely blunted and inappropriate. Content included very bizarre ideas of reference, persecutory and somatic delusions, ideas of body control, auditory and visual hallucinations. Prognosis with Lobotomy: 4. On the project ward she adjusted about as she did on other hospital wards. There was no change in her deterioration level. Operation: Venous ligation, 10/5/48. Postoperative Course: Pt stuporous with bilateral neurologic signs postoperatively. She died 10/7/48 without regaining consciousness.

PROJECT NO. B5 Schizophrenia, Paranoid type

A 51-year-old married female factory worker. Data concerning education and prepsychotic personality not available. In 1943, there was a gradual onset of ideas of reference, paranoid delusions, suspiciousness, and increasing excitability to the point of destructiveness at times. Her delusional system was loosely organized, but not bizarre. Hospitalization: 12/13/43 to 4/7/44. Discharged improved. No true remission. Readmitted 6/7/46. In the hospital she was suspicious, apprehensive, tense, and a definite paranoid trend was evident. Present hospitalization continuous. Delusional system maintained, but pt made fair hospital adjustment. No shock treatment. Project Psychiatric Findings: Paranoid trend with persecutory ideas involving landlady and unjust detention in hospital. Grandiose ideas of having royal blood. No hallucinations noted. Prognostic Rating: 1. On project ward pt was pleasant and cooperative. [illegible] n. Venous ligation, 10/6/48. During [illegible] was no detectable change in the pt [illegible] continued to reveal paranoid persecutory and grandiose delusions as easily as before operation and with reasonably appropriate display of affect. On the ward she continued to be

pleasant and cooperative. 3/21/49: Pt was attentive, cooperative; she continued to speak freely about her difficulties with her landlady and to acknowledge having "royal blood." She was working in the industrial building; and was making a reasonable ward adjustment. It was reported that no effort is being made to parole her. 6/8/49: Pt continued to request permission to go home. At times was irritable; at times smiling as she made the request. Same delusional material. Little spontaneity. Somewhat blunted affectively; somewhat evasive. On the ward she was less aggressive; was continuing to work in the industrial building. Improvement rating—5.

PROJECT NO. B6 Schizophrenia, Catatonic type

A 32-year-old, single male day laborer. Has always been quiet, self-conscious, shy, stubborn, worrisome; had few friends and little social or sexual life. Occupational history good. Beginning about December, 1936, he became tense; had insomnia; was increasingly seclusive; sat and stared at the wall; believed without justification that he had syphilis. Made a suicidal attempt; talked to himself; probably had auditory hallucinations; had definite ideas of persecution. Hospitalization: First admission, 4/7/37. At that time was confused, incoherent; had ideas of persecution and fixed delusions. Discharged improved, 1/15/39. No true remission. Readmitted 11/4/41. Was violent and overactive on admission. Present hospitalization continuous. 27 insulin comas; 9 ECT's in 1941, with slight improvement. Since 1942, has been dull, seclusive, perplexed, apprehensive, and at times required restraint. Project Psychiatric Findings: Tense, anxious, rigid posture, voice faint and hollow; tremors of hands, head, and at times, body; facies fixed. Much blocking; no spontaneity; speech inaudible at times. On the project ward there was slight improvement in the direction of increased socialization, interest in puzzles and magazines, and response to questions. Prognostic Rating for Lobotomy: 3. Operation: Venous ligation, 10/6/48. Postoperative Course: During the first 3—4 weeks following operation he was still catatonic in manner and attitude, revealing very little mental content. Pt became more active in art work during December. Painting was done at the request of the nurses. Productions quite stereotyped. 1/10/49: Unimproved. Pt showed same catatonic manifestations as preoperatively and of the same intensity. Quite blocked; voice barely audible; marked tremors of hands as well as head and body as before. Evasive, paucity of associations. Suggestions of automatic obedience. 3/21/49: Voice low, tremulous, indistinct; evasive about hallucinations. Stated his condition is "good." Sat with bowed head; talked in same low, tremulous, barely intelligible voice. Denied being ill in any way. No spontaneous remarks. Answers were brief and unelaborated as usual. According to ward reports he was making a borderline adjustment and working in the dining room. Improvement rating—5.

PROJECT NO. B7 Schizophrenia, Hebephrenic type

A 35-year-old, single female dry cleaning establishment worker. Occupational adjustment fair. Was always a shy, sensitive, withdrawn, stubborn person who was quite neat. In 1942, pt developed ideas of reference and persecutory delusions. Had ECT with a private physician, but failed to improve. Became more bizarre. Assaulted members of the family. Was excited, disturbed, confused. Hallucinations denied. Hospitalization: 3/14/45 to present. Silly, manneristic, referential. Loosely organized, persecutory and somatic delusions were present at the time of admission. In the hospital she was sporadically assaultive and destructive; otherwise adjustment was fair. No shock

week postoperatively her psychiatric condition was essentially the same as preoperatively. 1/10/49: Unimproved. Pt continued the delusional, hallucinatory pattern of essentially the same content. Was very silly, stereotyped, incoherent, and deteriorated. On the ward she was usually idle; no initiative or interest; was quite seclusive. 3/21/49: Silly, grimacing, shallow, inappropriate; whispered to self during interview. Better ward adjustment reported. 6/8/49. Pt silly, giggling, inappropriate, vacuous. Delusions and hallucinations involving the Spanish teacher, persisted. Much stereotyped use of certain phrases. Very manneristic. Condition on the ward reported as unchanged. Improvement rating—5.

PROJECT NO. B4 Schizophrenia, Paranoid type

A 50-year-old, married female domestic and waitress. Had always been friendly, fond of her children; showed good judgment, was a neat housekeeper. She was separated from her husband. Latter part of 1940, gradual onset of hypochondriacal ideas, a paranoid trend including the idea her food was poisoned by her mother, the doctors were trying to dope her; friends were throwing gas bombs on her. She was very referential. Had bizarre ideation and was openly hallucinating in the auditory sphere. Confusion and depression appeared, and she was hospitalized. Hospitalization: 1/18/41 to 2/6/42; 7/14/42 to present. 26 insulin comas, 2 Metrazol convulsions, 14 ECT's in 1941; 38 insulin comas, 14 ECT's in 1942. *No lasting improvement. In the hospital was a* conscientious dining room worker. Seclusive, tidy, and neat. There was steady deterioration. Project Psychiatric Findings: Pt cooperative, relatively pleasant, but completely incoherent and irrelevant producing a word salad. Facial expression was flat; affect was very definitely blunted and inappropriate. Content included very bizarre ideas of reference, persecutory and somatic delusions, ideas of body control, auditory and visual hallucinations. Prognosis with Lobotomy: 4. On the project ward she adjusted about as she did on other hospital wards. There was no change in her deterioration level. Operation: Venous ligation, 10/5/48. Postoperative Course: Pt stuporous with bilateral neurologic signs postoperatively. She died 10/7/48 without regaining consciousness.

PROJECT NO. B5 Schizophrenia, Paranoid type

A 51-year-old married female factory worker. Data concerning education and prepsychotic personality not available. In 1943, there was a gradual onset of ideas of reference, paranoid delusions, suspiciousness, and increasing excitability to the point of destructiveness at times. Her delusional system was loosely organized, but not bizarre. Hospitalization: 12/13/43 to 4/7/44. Discharged improved. No true remission. Readmitted 6/7/46. In the hospital she was suspicious, apprehensive, tense, and a definite paranoid trend was evident. Present hospitalization continuous. Delusional system maintained, but pt made fair hospital adjustment. No shock treatment. Project Psychiatric Findings: Paranoid trend with persecutory ideas involving landlady and unjust detention in hospital. Grandiose ideas of having royal blood. No hallucinations noted. Prognostic Rating: 1. On project ward pt was pleasant and cooperative. No significant change in condition. Operation: Venous ligation, 10/6/48. During the first 8 weeks following operation there was no detectable change in the pt's condition. 1/10/49: Unimproved. Pt continued to reveal paranoid persecutory and grandiose delusions as easily as before operation and with reasonably appropriate display of affect. On the ward she continued to be

out on a short shopping trip and created quite a scene in a store. Apparently she was responding to her paranoid delusional system. Improvement rating—5.

PROJECT NO. B9 Schizophrenia, Hebephrenic type

A 36-year-old male, married truck driver. Steady worker, good disposition, but was inclined to be quick-tempered and assaultive in an argument. Always somewhat jealous of wife. In 1942, while in a general hospital for surgical procedure, he became suspicious, developed frank ideas of reference, delusions of persecution, and became assaultive. Accused wife of adultery, Lesbianism, incest, poisoning his food, and assaulted her physically. Hospitalization: Admitted 3/12/44, and was markedly delusional, hallucinated, and at times excited. Hospitalization continuous. Had 35 insulin comas and 6 ECT's in 1944, but was unimproved. He has vegetated on the ward; needed much supervision, was sulky, talked to self a lot. Project Psychiatric Findings: Pt was paranoid, persecuted, hallucinated, dissociated and dilapidated. There was some incoherence. Hypochondriacal complaints and somatic delusions expressed. On the project ward the pt was idle, negativistic to test situations, but became slightly less resentful after several weeks. Prognostic Rating for Lobotomy: 2. Operation: 10/8/48, Venous ligation. Four weeks postoperatively the pt was the same as before operation—paranoid, aggressive, sarcastic. 1/10/49: Pt was agitated, paranoid, hypochondriacal; had somatic delusions, auditory hallucinations, and was moderately incoherent. On the ward he was idle and asocial. 3/21/49: Pt was irritable, scattered, illogical; showed some pressure of speech with a persecutory trend. Slightly more subdued than previously, but this was probably an oscillation. Adjustment on ward borderline. 6/8/49: Pt was irritable; responses were scattered, irrelevant; and he was very productive with some incoherence. Paranoid picture continued with a mixed persecutory and grandiose picture. Ward adjustment fair. He was idle and seclusive. Improvement rating—5.

PROJECT NO. B10 Schizophrenia, Paranoid type

A 42-year-old married female factory worker who left school after the eighth grade. Prepsychotic Personality: argumentative, irritable, stubborn, seclusive, worrisome, moderately alcoholic. In May, 1938, pt developed ideas of reference and persecution, became depressed, excited, agitated, and made several impulsive suicidal attempts. Hospitalized: June, 1938—November, 1938 and discharged as recovered. August, 1943 to December, 1943 and discharged as improved. Present hospitalization September, 1945 to present. Seclusive, asocial, idle, but tidy, resentful with occasional periods of excitement and assaultiveness, delusions of reference and persecution, and auditory hallucinations. Project Psychiatric Findings: Loosely organized, bizarre de- [illegible]

[illegible] scattering and irrelevance; moderately disorganized and deteriorated; auditory hallucinations. Prognosis with Lobotomy: 2. On the project ward she tended to remain seclusive, aloof, and haughty and occasionally expressed her delusions of persecution with irritation at the other patients. No operation. Condition unimproved at all times with psychotic fluctuations. In June, 1949 there was no change in condition. Improvement rating—5.

PROJECT NO. B10A Schizophrenia, Paranoid type

A 52-year-old married, female stenographer; began high school, but did not get along. Went to business school; then worked as a typist. Always has been

treatment in the hospital. Project Psychiatric Findings: Pt shallow, superficial, manneristic, grimacing, circumstantial, evasive, and probably hallucinated. Expressed feelings of being hypnotized, persecutory delusions, some grandiosity, and exhibited a good deal of silliness and inappropriate affect. At times she was incoherent. Prognostic Rating with Lobotomy: 2. On the project ward the pt had episodes of screaming, shouting, swearing, but at times was depressed. In general she was quiet and seclusive. Operation: Venous ligation, 10/7/48. 11/4/48: Abscess under bone flap evacuated. 11/26/48: Skull flap removed. 12/15/48: Pt continued to be silly, inappropriate, somewhat irrelevant and incoherent. She was evasive about hallucinations and delusions of which she complained preoperatively. She was in slightly better contact on the ward. 1/10/49: Slight improvement. Pt was in somewhat better contact emotionally; less incoherent and less dominated by delusional and hallucinatory experiences. On the ward she was more pleasant and tractable. She continued to be quite shallow, superficial, vacuous, silly, inappropriate, and evasive. 3/26/49: Pt had been home on convalescent leave for 3 weeks and came to the Psychiatric Institute for interview. Pt pleasant, cooperative; had little spontaneity. She made many incoherent remarks, was silly and produced some neologisms. Relatives reported she was quite untidy and paid little attention to her appearance in contrast to relative neatness before operation. She was quite stubborn, more silly than before operation, more preoccupied, and less alert and enthusiastic. She confabulated to visitors. 6/18/49: Pt was silly, evasive, manneristic, vacuous, superficial, scattered, hallucinations denied. According to relatives, the pt was irritable, verbally aggressive; assaultive, very negativistic. At home wrote senseless notes; did little housework; ate ravenously. Much of her talk was incoherent. Sister had seen no improvement at any time since pt was discharged from the hospital and felt condition was the same as in 1945. Improvement rating—5.

PROJECT NO. B8 Schizophrenia, Paranoid type

A 47-year-old, married, female file clerk. Is said to have always been quiet, reserved, a poor mixer, a compulsive mother and housekeeper. In May, 1936 she complained of being bothered by flashing lights, being followed, poisoned, *and mixed up in a vice racket. She felt that Roosevelt was going to be* kidnapped. Hospitalization: 6/12/36 to present. No shock treatment. Was tidy, clean, quiet, neat, and occupied doing needlework. Irritability and delusions most prominent when with her family. Project Psychiatric Findings: Pt very evasive, irrelevant, poorly organized; denied delusions and hallucinations though referred to members of the hospital staff as investigators. Affect shallow, some silly smiling; preoccupied. Prognostic Rating for Lobotomy: 3. On the project ward she was quiet, cooperative, seclusive. Sometimes suspicious, resentful and irritable. Operation: Venous ligation, 10/7/48. Following operation there were oscillations in clinical picture characterized by affective blunting, but pleasant cooperativeness on the one hand and resentful irritability on the other. 1/10/49: Pt unimproved. Continued shallow, superficial, highly paranoid and delusional; still evasive. Ward behavior usually cooperative, but punctuated with occasional irritable paranoid outbursts. 3/21/49: Unimproved. Affectively blunted, inadequate, superficial, uncommunicative; denied paranoid delusional content. Was somewhat irrelevant and exhibited silly laughter. 6/8/49: Pt continued superficial and emotionally shallow as before. There were ward reports of efforts being made to parole this pt. Pt did not wish to return to her husband and he was not willing to take her. It was considered by Social Service that a sister in Philadelphia might take her. Recently pt went

ECT's in 1941, with improvement. Project Psychiatric Findings: Inappropriate affect, silly smiling and laughter, some distractability, overproductive, much irritation, and resentment. Loosely organized system of being poisoned, assaulted, deprived of everything. Somatic delusion that her blood was not right. Prognostic Rating with Lobotomy: 2. On the project ward her course was variable. At times cooperative and pleasant with many short periods of agitation and excitement during which she was dominated by paranoid ideation directed against staff, testing procedures, and operation. Operation: Venous Ligation, 10/11/48. During the first 3 to 4 weeks following operation pt followed a course essentially the same as preoperatively. 1/10/49: Unimproved. Pt was still highly paranoid with much silly, inappropriate behavior. Continued to show oscillations in ward behavior between cooperation and aggressiveness and destructiveness on a paranoid basis. 3/21/49: Unimproved. 6/8/49: Unimproved. Pt spoke in an agitated, irrelevant way, and there was a good deal of anger and irritability. She referred to persecutory ideas; spoke of internal injuries of a sexual kind. Reported to be very noisy, overactive, and destructive on the ward. Improvement rating—5.

PROJECT NO. B12 Schizophrenia, Catatonic type

A 26-year-old, single, female clerical worker. Worked as a bookkeeper for 4 years. Occupational adjustment good. Described as domineering, stubborn, sensitive, bashful with men. About January, 1945, she became disagreeable, nagging, untidy, assaultive, referential; had persecutory delusions, ideas of reference, of being poisoned, and had auditory hallucinations. Hospitalization: 11/29/45 to present. Throughout pt was seclusive, withdrawn, untidy, but fairly cooperative on the ward, becoming excited at times without apparent reason. There were continuous delusions and auditory hallucinations. No shock treatment. Project Psychiatric Findings: Pt flat, underproductive, rigid, hallucinated; described delusions of poisoned food, many ideas of self-condemnation. Prognostic Rating with Lobotomy: 1. On the project ward she was quiet, seclusive, compulsive. Was unable to stand dirt and was continuously mopping and sweeping. Operation: Venous ligation, 10/11/48. The fourth week, after operation she was more relaxed and less anxious, more productive; less dominated by hallucinations. On ward more spontaneous and friendly. 1/10/49: Unimproved. Pt displayed paranoid delusional content and was markedly influenced by [illegible] incoherent, affect was inappropriate. 3/21/4[illegible] listinct. Appeared surprised to see examiners. [illegible] she was tortured by the voices and was still irritable; wanted to leave the hospital. Affect shallow and superficial. Contact slightly improved. Report stated pt was on the disturbed ward; worked at times, but was frequently noisy. 6/8/49: Pt in good social contact. Productions somewhat scattered. Self-absorbed at times. She continued to have hallucinations and delusions. Reported as better on ward, but was silly, demanding, though reasonably cooperative. She needed a great deal of supervision. Improvement rating—5.

PROJECT NO. B13 Schizophrenia, Hebephrenic type

A 32-year-old, single, male building dispatcher. Prior to illness pt was even tempered, sensitive, somewhat seclusive, but had good judgment. Was cautious and conservative, religious; read a lot; participated some in sports; and was neat. Occupational adjustment good. In September, 1939, the pt be-

a shy, seclusive person. Has had many episodes of mental illness. Details not known. Hospitalized at ages, 32, 36, 42, 48, 49 with sexual, religious, grandiose, persecutory delusions, auditory and visual hallucinations. Present Hospitalization: 5/23/45 to present, with 6 weeks' parole period in 1945. Has been tidy, neat, gregarious, cooperative most of the time. Has periods of resentment during which she becomes excessively demanding, and these are associated with her delusions and hallucinations. No shock treatment at hospital. Project Psychiatric Findings: Somatic, persecutory, grandiose delusions and hallucinations involving a "Mr. Campbell." Bizarre ideas of body being affected. Ideas of reference. Affect reasonably well preserved with responses appropriate to delusional content. Prognosis with Lobotomy: 2. On the project ward she was pleasant, cooperative, sociable; spoke freely of Mr. Campbell and his affecting her. Operation: Venous ligation, 10/8/48. The third postoperative day an epidural clot was released. Subsequently there was a wound infection. The fourth week improved mentally, but irritable concerning wound infection. More relaxed emotionally and less dominated by hallucinations than before operation. Did not mention them on ward. 1/10/49: Slightly improved. Based on diminution in frequency and intensity of auditory hallucinations during the past month. Otherwise she appears unchanged emotionally and intellectually. However, on the ward she was again speaking of Mr. Campbell frequently. She was quiet, cooperative, neat. Had little initiative or interest. 3/21/49: Pt had been on parole in family care for a few weeks and came to the hospital for interview. She continued euphoric, somewhat silly and unconcerned. Hallucinations and delusions involving Mr. Campbell continued. Pt elaborates the material in a vague, confused fashion. The woman with whom the pt was living described the pt as resistive. 6/8/49: Pt continued silly, euphoric, maintained a fairly relevant conversation; was in good social contact with the examiners; continued to have delusions and hallucinations concerning Mr. Campbell. The woman with whom she lived reported that pt was all right if left alone, but remained idle aside from washing and ironing her own clothes. She was neat; ate well; slept well; refused to go out. When visited by her relatives, she became quite angry. 8/5/49: Telephone conversation with Director of Social Service, Greystone: In July, pt worked for 3 weeks caring for the young children of a widower, living in her employer's home. She obtained the position without consulting Greystone physicians. The latter advised against her assuming responsibility for the children while the father was on vacation and pt was relieved of her job. She returned to her former family-care home and was said to be interested in finding another job. Improvement rating—4. This patient has had many psychotic episodes in the past 21 years, usually with spontaneous remission and subsequent relapse.

PROJECT NO. B11 Schizophrenia, Catatonic type

A 32-year-old single, female laundry worker, who completed the eighth grade at school. Described as having been friendly; quite particular about appearance and the care of her home. Had some male friends, but was not seriously interested in any of them. Occupational adjustment fair. In 1941 she gradually became fatigued, restless, unable to sleep. Was preoccupied, seclusive; developed multiple paranoid delusions of a persecutory type as well as [illegible] essed; lost interest in per- [illegible] Discharged as improved. [illegible] then relapsed. Had feel- [illegible] admitted 1/8/45. Present [illegible] ly. 25 insulin comas, 10

Was sensitive and cried easily; quite interested in her personal appearance. Never confided in anybody. Went out with boys. Gradual onset, 1943. She became seclusive; acted strangely; had a crucifixion fantasy; was irritable. Thought she had syphilis. Became depressed. Failed to respond to shock treatment in private sanitarium. Hospitalization: Admitted 2/5/47. 2 courses each of insulin coma treatment and ECT with only transient improvement. Throughout hospitalization she was always on the disturbed ward; assaultive toward the other pts. Project Psychiatric Findings: Tense, evasive, defensive in interview. Frequent inappropriate smiling and laughter. Posture stilted and angular. Frequently expressed desire to go home. No other spontaneity. Vague concerning somatic and persecutory delusions and visual and auditory hallucinations. Prognostic Rating for Lobotomy: 2. On the project ward she had unpredictable oscillations; at times was contented, playing games; other times was excited, assaultive, with screaming, door slamming. Operation: Thermocoagulation, 10/15/48. Her preoperative status was attained about November 10th. She was preoccupied, blocked, resentful, suspicious, verbally defiant and gave the stereotyped mental content of the preoperative days. 1/10/49: Pt unimproved. 3/21/49: Pt too disturbed to be brought to building where postoperative interviews were conducted and she was visited on the security ward where she was seen in a camisole. She was uncommunicative; wore an inappropriate, defiant smile. She made some stereotyped comments of the preoperative kind concerning "home, sweet home" and wanting to go home. She spoke of sexual and persecutory delusions involving the hospital staff. 6/8/49: Pt very disturbed; in camisole and seclusion most of the time. Interview unproductive. She was negativistic and blocked and appeared to be quite suspicious of the examiners. Improvement rating—5.

PROJECT NO. B16 Schizophrenia, Hebephrenic type

A 30-year-old separated female office worker. Many different jobs. She was known as a cheerful, practical, serious, religious, and at times seclusive individual. She married against the wishes of her family and was deserted by her husband in 1943. 1940—gradual onset of illness. Pt was high strung and nervous, restless, worried; lost weight; would sit and stare into space. Cried without apparent cause. In 1943 she was upset; cried continually. Affect was inappropriate. Frequently became excited; threatened suicide; gradually became confused, depressed, disoriented. Was hospitalized 2/19/43. Transferred to Greystone Park State Hospital 11/5/43. Present hospitalization continuous. No shock treatments. Gradual deterioration. Much of early content was a paranoid trend against her family. Course of illness punctuated by unpredictable outbursts of temper against self and others. Had visual and auditory hallucinations. Project Psychiatric Findings: Stilted, manneristic, inappropriate, shallow, blunted, apathetic, much silliness, loosely organized persecutory delusions, auditory hallucinations, much sexual content; bizarre ideation. [illegible] the project ward pt's level of deterioration [illegible] industrious in ward routine. Operation: Therm[illegible] fourth postoperative week she had regressed to preoperative status with irritability, resentment, evasiveness, impairment of emotional contact and paranoid ideation. 1/10/49: Unimproved. 3/21/49: Silly, inadequate, [illegible] scattered, time disorientation [illegible] 6/8/49: Aloof, disinterested, [illegible] flippant, scattered. Concerning [illegible] I said I had the skull of an old woman. I can't think any more. I'm illiterate." Improvement rating—5.

came confused, *frightened*, irritable, *withdrawn*, untidy; was excited, became violent, talked of suicide, and was silly at times. There were persecutory delusions and bizarre somatic delusions as well as auditory and visual hallucinations. Hospitalization: 9/25/40 to present. Was disturbed, irritable, quarrelsome, hallucinating most of the time. 52 insulin comas and 15 Metrazol convulsions in 1940; unimproved. Project Psychiatric Findings: When first seen, pt was grimacing, posturing, completely incoherent, producing a word salad with many neologisms; actively hallucinating; many bizarre delusions. On the project ward pt was quiet, seclusive, and expressed many paranoid ideas. Prognostic Rating with Lobotomy: 4. Operation: Thalamotomy, 10/13/48. Through November and December, 1948, pt was definitely improved as characterized by disappearance of word salad, improvement in intellectual organization, diminution of agitation, and better cooperation on the ward. Early in January, 1949, he relapsed and presented the preoperative picture. 3/21/49: He was just as incoherent and irrelevant as preoperatively. On the ward he was assaultive, destructive, and required maintenance shock therapy. 6/8/49: Pt was in fair contact, but frequently was preoccupied; stared about the room; wore an impassive, somewhat perplexed expression. Very little spontaneity. Responses were brief. He was vacuous, shallow. He seemed to have a genuine memory defect for the content of his preoperative word salad. On the ward he needed a good deal of personal care and was idle. Improvement rating—5.

PROJECT NO. B14 Schizophrenia, Hebephrenic type

A 26-year-old, single male odd-job worker. Was always quick-tempered; stubborn, sensitive, somewhat seclusive, no interest in girls, suspicious; had one friend. November, 1942, pt lost his job in association with staying out late, drinking, and a personality change. He seemed tired, depressed. Was often preoccupied. Spoke of hearing God talk to him. Became destructive, belligerent, and had many delusions of being persecuted. Hospitalization: 4/24/43 to present. 34 insulin comas and 21 ECT's in 1943; not improved. Throughout hospitalization he was silly, superficial, obviously hallucinating, and often in a camisc[illegible]ized, dilapidated, disoriented, impove[illegible] quite vague about hallucinations. [illegible] Prognosis for Lobotomy: 4. On the project ward pt collected many cardboard boxes in his pockets and was inclined to throw rolls of paper in the toilets and clog them. Operation: Thalamotomy, 10/14/48. Fourth week after operation pt more able to care for himself; more friendly and interested in pts and staff. He was cooperative, answering questions readily, but briefly. 1/10/49: Unimproved. Pt continued deteriorated emotionally and intellectually. He was apathetic, dull, disinterested, completely vacuous and devoid of mental content. There were frequent periods of irritability, verbal aggressiveness. On the ward he was idle and asocial. Untidy and disinterested. 3/21/49: Pt tense, evasive, resistive. Hallucinations and delusions persisted and according to ward reports pt was assaultive. 6/8/49: Pt was shallow, vacuous, inappropriate, and evasive. All his responses were brief, restricted, vague, and non-communicative. He stated he was 16 years old. Was evasive about delusions and hallucinations. Ward reports stated that pt had tried to start fires on the ward. He was less untidy than before. Improvement rating—5.

PROJECT NO. B15 Schizophrenia, Catatonic type

A 30-year-old, single female office worker. Occupational adjustment fair. Described as having been sociable, friendly, frank, and outspoken, but stubborn.

chondriacal ideas and auditory hallucinations with an agitated reaction, became seclusive and depressed, expressed ideas of reference and persecutory delusions. After being drafted into the Army in 1941, he was discharged after 3 months because of severe excitement and impulsive suicidal attempts. Hospitalization: August, 1941 to the present time. In late 1941 he received 44 insulin comas and 11 ECT's without improvement. Although seclusive and withdrawn, he did some light work under supervision. There was a gradual, progressive intellectual and emotional deterioration. Project Psychiatric Findings: Pt was extremely dull, apathetic, blunted, silly, inappropriate, manneristic, and stereotyped. Productions were irrelevant and grossly incoherent, without goal or any leading thought. He expressed a mild grandiose and paranoid trend and admitted auditory hallucinations. Intellectual and emotional deterioration were severe. Prognostic Rating with Lobotomy: 4. On the project ward he continued idle, seclusive, silly, inappropriate, and had occasional short periods of moderately excited reaction to persecutory ideation and auditory hallucinations. Operation: Transorbital lobotomy, 10/28/48. In the first week following operation, he showed a moderate degree of sluggishness and inertia. He then reverted in a few weeks to his preoperative status and maintained this up to the time of the last observation. In June, 1949, he was still preoccupied, self-absorbed, and flat and apathetic, manneristic, and had much delusional content, and continued to show severe fragmentation. Improvement rating—5.

PROJECT NO. B20 Schizophrenia, Hebephrenic type

A 27-year-old single male factory worker, who finished 3 years of high school at the age of 16. Prepsychotic Personality: Industrious, sensitive, neat, passive, and brooding. In 1941 pt gradually became hypochondriacal, preoccupied, and self-absorbed, with agitated reactions to auditory hallucinations, and loose ideas of persecution. Hospitalized: 9/17/42 to 2/16/43; discharged as improved after 14 insulin comas and 13 ECT's in 1942. Present admission, 11/16/45, to present. Silly, superficial, bewildered and grimacing; moderate depression; persecutory and somatic delusions, auditory hallucinations with excitement. Escaped from hospital twice to evade auditory hallucinations. Project Psychiatric Findings: Pt was vacuous, bland and flat, silly, inappropriately euphoric, grimacing, bewildered, and stereotyped. Productions were irrelevant, circumstantial, grossly incoherent, literal and concrete. He expressed feelings of confusion in his thinking processes, visual and auditory hallucinations, and mild grandiose trends. Prognostic Rating with Lobotomy: 3. On the project ward there was a slight improvement in social contact, but he continued essentially vacuous, idle, and seclusive. Operation: Transorbital lobotomy, 10/28/48. Apart from a very slight improvement in the first postoperative week, this pt demonstrated no significant change. When last seen in June, 1949, he was still flattened, bland, and euphoric, often silly, perplexed, showed gross scattering with neologisms, marked disorganization, admitted auditory hallucinations, and displayed a highly delusional mental content. Improvement rating—5.

PROJECT NO. B21 Schizophrenia, Hebephrenic type

A 33-year-old, single female with no occupation, who finished grammar school. Prepsychotic Personality: Stubborn, resentful, sensitive, worrisome, and seclusive, but not particularly shy. In July, 1941, she gradually became more suspicious, hostile, and agitated, and expressed numerous persecutory

PROJECT NO. B17 Schizophrenia, Hebephrenic type

A 33-year-old, married female who had 8 years of schooling. Prepsychotic personality: Industrious, honest, but shy, self-conscious and asocial. Occupational adjustment good, but much marital difficulty leading to a separation from her husband. In September, 1943, the pt developed excessively religious interest, suspicion, and persecutory ideas, bizarre behavior, auditory hallucinations with reactions, and showed sporadic depressions. Hospitalization: 3/28/44, to present. Childish, silly, and inappropriate; vague and contradictory; a loose delusional system with sexual fantasies and a minor persecutory element. Usually cooperative and tractable, disturbed on short visits home. Project Psychiatric Findings: Pt was silly, childish, inappropriate, manneristic, stereotyped, incoherent, and probably having auditory hallucinations. Blocking, irrelevance and disorganization were prominent; the mental trend was a loose, odd fantasy structure. Prognostic Rating with Lobotomy: 4. On the project ward she continued idle most of the time, untidy, silly, childish, and occasionally excited with attempts to disrobe. Operation: Transorbital lobotomy, 10/28/48. She continued silly, fragmented, disorganized, manneristic, and stereotyped with unchanged ward behavior. In June, 1949, her condition was identical with that before operation. Improvement rating—5.

PROJECT NO. B18 Schizophrenia, Hebephrenic type

A 28-year-old, single, female factory worker, who left high school at the age of 16 after 3 years. Prepsychotic Personality: Shy, quiet, seclusive, worrisome, aloof, and without apparent interest in the opposite sex. In July, 1943, pt began to complain of fatigue, insomnia, and generalized weakness; became overtalkative, expressed hypochondriacal ideas, a paranoid trend, and reacted to auditory hallucinations. Hospitalization: 8/26/43, to 1/22/45, discharged as improved after 31 insulin comas in June, 1944, and 17 ECT's in October, 1944. Present admission from 3/28/46, to present. Readmitted after suicidal attempt at home; bewildered, apprehensive, suspicious, irrelevant, scattered and had a loose paranoid trend. Project Psychiatric Findings: Pt extremely dull, vacuous, flat, apathetic, unspontaneous, grossly inappropriate with impaired associations, blocking, evasion, and signs of a severe thinking disorder. Productions were very scanty and vague, consisting mostly of evasions and denials. She exhibited evidences of auditory hallucinations including music, ideas of mind control, thought reading, and body tampering. Special affect displays were usually apprehension and suspicion. On the project ward she continued idle and seclusive, apathetic, and blunted, grossly disorganized, and sometimes expressed loose ideas of reference. Prognostic Rating with Lobotomy: 3. Operation: Transorbital lobotomy, 10/28/48. Pt continued essentially as before, idle, seclusive, and vacuous. In June, 1949, she became slightly more energetic and cooperative inside the hospital and had a successful visit at home for one week, displaying more interest in her personal appearance and participating in a shopping trip. Otherwise her condition was unchanged. Improvement rating—5.

PROJECT NO. B19 Schizophrenia, Hebephrenic type

A 34-year-old single male machine shop worker who completed 8 years of schooling at the age of 14. Prepsychotic Personality: Active and friendly, cheerful, not worrisome, average intelligence, good memory, enjoyed dancing, but had no steady relationship with girls. In 1931, pt gradually developed hypo-

with frequent sardonic smiling. Unspontaneous, evasive, blocked, negativistic, and moderately scattered. Many loose persecutory delusions, sexual fantasies, and auditory hallucinations. Prognostic Rating with Lobotomy: 2. On the project ward, she was less aggressive, but continued aloof, suspicious, uncooperative, and defiant. Operation: Transorbital lobotomy: 10/28/48. No significant response to operation at any time. In June, 1949, she continued to be hostile, suspicious, evasive, manneristic, stereotyped, and fragmented with the same persecutory delusions and auditory hallucinations. Improvement rating—5.

PROJECT NO. B23 Schizophrenia, Hebephrenic type

A 29-year-old, single female nun who completed grammar school and then entered a convent at the age of 16. Prepsychotic Personality: Pleasant, sociable, even-tempered, industrious, happy; became a nun because "God called her." In January, 1941, the pt began to laugh inappropriately, became silly, talked to herself a great deal, became excited, aggressive, and expressed loose and bizarre persecutory and grandiose ideas. Hospitalization: 12/8/42 to present. Silly, superficial, and inappropriate, bizarre paranoid ideation. Cooperative and occasionally carried out ward duties, although at times irritable and superior. Project Psychiatric Findings: Essentially shallow although at times showing anger and tension; inappropriate and silly; suspicious. Profusely productive with circumstantiality, irrelevance, and incoherence. Expressed a loose, fantastic persecutory and grandiose system, with auditory hallucinations. Prognostic Rating with Lobotomy: 3. On the project ward social contact was somewhat improved, but she expressed her paranoid ideas quite freely. Operation: Transorbital lobotomy, 10/28/48. Pt exhibited slight improvement through March, 1949, consisting of decreased tension, better emotional contact with others and slight decrease in incoherence. By June, 1949, she had returned to her preoperative condition with gross incoherence, the same paranoid, flatness, inappropriateness and silliness, and moderately disturbed reactions to her auditory hallucinations, and the same ward behavior. Improvement rating—5.

PROJECT NO. B24 Schizophrenia, Paranoid type

A 44-year-old, single female sales clerk who graduated from grammar school at the age of 15 or 16. Prepsychotic Personality: Sensitive with feelings of inferiority, hostile toward the mother, but industrious, affectionate, cheerful, trusting, sociable, and friendly; intelligent, stubborn. In September, 1942, pt became progressively irritable, developed ideas of reference and persecution, became excited, agitated, silly, and untidy in appearance. Hospitalization: 9/3/43, to present time. In 1944, received 21 ECT's and 48 insulin comas without significant improvement. In hospital, childish, suspicious, resentful, irritable; tried to escape several times, once fracturing spine in jumping from window in [illegible] ate, silly, irritabl[illegible] Productions vagu[illegible] atology. Heavily [illegible] ditory hallucinations denied. [illegible] tion. On the project ward, pt b[illegible] to routine and quite actively so[illegible] rating of 4 in spite of continuat[illegible] and some irritability. In June, 1949, she had relapsed to her initial condition and was still trying to escape from the hospital. Improvement rating—5.

and grandiose ideas. Hospitalization: 7/2/41, to 12/8/41, and discharged as improved after 46 insulin comas and 35 ECT's in 1944. Present admission, 1/9/48, to present. Noisy with pressure of speech, excited and violent, in restraint; this behavior alternated with periods of cooperation and compliance. Scattered, stereotyped, and evasive. Project Psychiatric Findings: Blank and vacuous; haughty, suspicious and antagonistic; silly and inappropriate; shallow despondency, moderately evasive, blocked, circumstantial and irrelevant; pressure of speech when not negativistic; some automatic obedience. Expressed loose grandiose and persecutory ideas with sexual fantasies and reluctantly admitted auditory hallucinations. Prognosis with Lobotomy: 2. Project ward behavior ranged from angry paranoid outbursts to stilted obedience. Operation: Transorbital lobotomy, 10/28/48. Pt's condition showed no significant change at any time following operation and she has continued in essentially the same fashion throughout the period of observation. In June, 1949, she was inappropriate, manneristic, stereotyped, highly delusional with auditory hallucinations, evasive and negativistic, and assaultive. Improvement rating—5.

PROJECT NO. B22 Schizophrenia, Hebephrenic type

A 36-year-old married female clerical worker with 4 or 5 years at a collegiate institute. Prepsychotic Personality: Suspicious, sensitive, stubborn, easily angered, sulky, but neat and a good housekeeper. In September, 1937, pt became seclusive, preoccupied, disinterested, moody, untidy, developed fear of germs, expressed hatred for her mother, behaved oddly with her child, appeared bewildered, expressed somatic and persecutory delusions, and probably had auditory hallucinations. Hospitalization: 8/29/41, to present. Shallow reactions to vague loose paranoid ideation with some specific phobias; neat, cooperative, and a fairly reliable worker in a housekeeping job. Project Psychiatric Findings: Tense, anxious, despondent, bewildered, and suspicious in a shallow fashion. Productions irrelevant, circumstantial, and grossly scattered. Expressed loose, bizarre paranoid and somatic delusions; had auditory hallucinations. Prognostic Rating with Lobotomy: 3. On the project ward, seclusive, aloof, appeared to be having frequent auditory hallucinations. No operation. Nearly always refused to be interviewed because of anxiety and suspicion. No change in condition. In June, 1949, she was tense, fairly vacuous, shallow; incoherently expressed the same highly delusional content and admitted that the auditory hallucinations were unabated. Improvement rating—5.

PROJECT NO. B22A Schizophrenia, Hebephrenic type

A 33-year-old, married female factory worker, who finished 2 years of high school. Prepsychotic Personality: Pleasant and sociable but sensitive, prejudiced, stubborn, fault finding, and impulsive. In 1931, pt thought she had a sexual disease and was hospitalized at Trenton SH for 9 months. In 1936 after an abortion she became preoccupied, depressed, suspicious, antagonistic toward her husband, afraid of her relatives, expressed numerous persecutory delusions; refused to eat, had delusions of being married to a doctor, and left her husband voluntarily. Hospitalization: 9/26/40, to 12/31/40; paroled as improved after 26 insulin comas. Present admission from 2/15/41, to present. In 1941, 19 ECT's and in 1946, 21 Metrazol seizures without significant improvement. [illegible]
hallucinatior [illegible]
manneristic, [illegible]

frequently irritable; masturbated openly; quite amiable and sociable in general. Project Psychiatric Findings: Amiable and whimsically inappropriate, and shallow, intensely manneristic and stereotyped, with some echolalia and echopraxia. Productions spontaneous but quite irrelevant, distractable, scattered, and with occasional neologisms. Indirectly expressed ideas of reference and influence, bizarre somatic delusions, a mildly expansive trend, auditory and possibly visual hallucinations. Prognostic Rating with Lobotomy: 2. No operation. On the project ward he continued queer, odd, idle, self-absorbed and preoccupied, untidy, but apparently self-contented. In June, 1949, he was just as dilapidated as initially and was again requiring restraint for occasional periods of excitement. Improvement rating—5.

PROJECT NO. B28 Schizophrenia, Hebephrenic type

A 30-year-old single female hairdresser, who completed 3 years of high school. Prepsychotic Personality: Pleasant, but easily angered and somewhat overactive. In July, 1940, pt gradually became progressively seclusive, evasive, preoccupied, dep [illegible]
present. Course mar [illegible]
odd sexual fantasies, [illegible]
ject Psychiatric Findings: Apathetic, shallow, dull, inappropriate, grimacing, manneristic, and stereotyped. Responses brief, evasive, irrelevant, and scattered. Content extremely scanty with much denial; called self-graduate of Princeton University; auditory hallucinations. Prognosis with Lobotomy: 4. On the project ward she continued seclusive, idle, apathetic, blunted, inappropriate, and expressed no mental content except desire to go home. Operation: Transorbital lobotomy, 10/28/48. Postoperative Course: No significant change at any time following operation. In June, 1949, still preoccupied, manneristic, incoherent, dull, inappropriate and intellectually vacuous. Improvement rating—5.

PROJECT NO. A8 Schizophrenia, Pseudopsychoneurotic type

A 30-year-old, single male cook who completed 4 years at Jesuit Novitiate. Prepsychotic Personality: Quick-tempered with short bouts of anger, selfish, sensitive, anxious, pessimistic, ambitious, and religious. Maternal aunt, hebephrenic schizophrenia at Greystone, 1923 to present. December, 1940, pt left Novitiate because of increasing nervousness and "stomach trouble," excessive anxiety with perspiration, intermittent depressions with thoughts of suicide, tension, and severe inferiority feelings. Hospitalization: Pilgrim S.H., N. Y., February—June, 1942, discharged as much improved. At Greystone Park S.H. May 29, 1944, to April 22, 1945, receiving 39 insulin comas and 19 ECT's without significant improvement. Readmitted 2/12/46 to present; 17 ECT's in 1946, without benefit. On 5/16/47, on the first Columbia-Greystone project he received a bilateral frontal topectomy with removal of parts of Brodmann's areas 8, 9, 10, and 46. He was rated as moderately improved after the operation but developed occasional grand mal seizures. Project Psychiatric Findings: Pt was labile, irritable, suspicious, and resentful; anxious and tense; despondent; at times ingratiating. Productions usually relevant and coherent, without evidence of thinking disorder, but with much evasion and blocking. Gave a reasonably accurate account of his prolonged illness and hospitalization. Symptomatology elicited consisted of anxiety, tension, inferiority feelings, irritability, paranoid attitude, and depression. Stated that first operation helped relieve

PROJECT NO. B25 Schizophrenia, Catatonic type

A 32-year-old single male Marine who graduated from high school at about the age of 19. Prepsychotic Personality: Active, athletic, very economical, sociable, friendly, not stubborn or selfish. In 1943, while pt was a Marine, he developed loss of interest, preoccupation, increase in self-consciousness, seclusiveness, despondency and depression, loose paranoid ideation, and experienced disparaging auditory hallucinations. Hospitalization: 8/22/46, to the present time. In 1946 received 36 ECT's and 48 insulin comas with slight improvement In hospital auditory hallucinations and paranoid ideation continued but was a regular worker on hospital grounds, socialized well and required little supervision. Project Psychiatric Findings: Cooperative, but very anxious, tense, in a rather dull fashion. Productions coherent and logical. Complained of ideas of reference and persecution, auditory hallucinations, alternating periods of depression and excitement, and impairment of his thinking powers. Prognostic Rating with Lobotomy: 1. No operation. On the project ward he made a satisfactory adjustment, was quite social, pleasant, and cooperative. He received improvement ratings of 4 in January and March, 1949, in spite of the fact that his other manifestations were essentially unchanged. He was discharged as a voluntary pt and did not respond to a follow-up letter in June, 1949. His hospital physician reported that he was working satisfactorily as a farmhand. Improvement rating—4.

PROJECT NO. B26 Schizophrenia, Paranoid type

A 52-year-old, divorced female waitress who finished 2 years of high school. Prepsychotic Personality: Nervous, quick-tempered, and extravagant, but an excellent housekeeper. In 1936, pt gradually became suspicious of friends, accused her husband of infidelity, developed ideas of reference and persecution, particularly in a sexual context and expressed bizarre somatic delusions. She became impulsive, agitated, and once threatened suicide. Hospitalization: 12/6/38, to the present time. Highly paranoid delusional, probably with auditory hallucinations; at times highly disturbed, requiring restraint; tried to escape from hospital, wrote numerous letters to lawyer for release. Project Psychiatric Findings: Suspicious, angry, and resentful at being detained in the hospital; slight inappropriateness. Pressure of speech in a rambling, circumstantial, irrelevant, scattered, and disorganized fashion. Expressed numerous, loose ideas of reference and persecution with thought-theft; admitted auditory and tactile hallucinations; had many somatic complaints. Prognosis with Lobotomy: 2. No operation. On the project ward her condition was unchanged. She was transferred back to her original building in October, 1948, because she was too disturbing an influence on the project ward. In June, 1949, her condition was exactly the same as on first observation. Improvement rating—5.

PROJECT NO. B27 Schizophrenia, Hebephrenic type

A 28-year-old single, male without occupation, who graduated from high school. Prepsychotic Personality: quick-tempered, sensitive, fussy, shy, seclusive, and without apparent sex interest. In February, 1938, pt became progressively seclusive, preoccupied, irritable, depressed, hostile toward his father, excited, and agitated in reaction to auditory hallucinations; also some vague, grandiose ideas. Hospitalization: 8/4/38, to 12/3/39; discharged as improved after 56 insulin comas and 12 Metrazol seizures in 1939. Second admission, 4/27/42, to present. On this admission, quite fragmented, untidy,

not alter the aggressive-destructive behavior. Pt transferred to Greystone October, 1948, for operation. Project Psychiatric Findings: Tense, restless, embarrassed, with much smiling and giggling suggestive of inappropriateness. Productions were coherent and relevant, without evidence of thinking disorder, but with occasional evasion and contradictions. Gave a fairly detailed account of early anxiety and shyness, inferiority feelings, visual hallucinations, fears of being attacked and killed, admitted aggressive and destructive behavior on a paranoid basis. On the project ward she was tractable during the several days' observation prior to her operation. Operation: Bilateral frontal topectomy, 10/19/48. After a moderately severe organic snydrome lasting several weeks pt again became anxious, irritable, suspicious, antagonistic, assaultive, and destructive. In addition in January, 1949, signs of organic impairment were present in the form of dullness and restriction of associations. She was transferred back to MSH in January, 1949. Follow-up letters from this hospital in March and June, 1949, report that the pt is unchanged: assaultive, destructive, suicidal, with a severe paranoid attitude; also some deterioration of the intellectual faculties but unable to cooperate for testing. Improvement rating—5.

homosexual and masturbation conflicts, but that he became more explosive, despondent, and entertained suicidal thoughts. On the project ward he was tense and apprehensive, alternately overcompliant or verbally aggressive; superior attitude to other pts. Operation: Extension of first topectomy operation, 10/18/48. After several weeks during which he was dull, listless, unproductive, incontinent of urine and complained of impaired concentration he gradually resumed his preoperative condition. In June, 1949, he stated spontaneously that he was unimproved; complained of tension and explosiveness, anxiety, especially in relation to sexual issues, and suicidal thoughts. On his ordinary hospital ward, he became more aggressive since the second operation and has had about one spontaneous generalized seizure per month. He has also received several therapeutic convulsions by ECT. Improvement rating—5.

PROJECT NO. A10 Schizophrenia, Hebephrenic type

A 45-year-old single male truck driver, who left high school in his last year. Prepsychotic Personality: Sociable and talkative, but jealous, sensitive, stubborn, and easily angered. There was never much contact with the opposite sex. In September, 1928, he gradually became preoccupied, self-absorbed, restless, agitated, showed pressure of speech, worried about a girl, refused to eat, finally becoming highly disturbed and assaultive. Hospitalized 6 weeks in 1928, and continuously since May, 1932. Treated unsuccessfully with 30 insulin comas and 15 Metrazol seizures in 1939, and 10 ECT's in 1941. Seclusive, preoccupied, untidy, vague, incoherent; paranoid ideation and auditory hallucinations; occasional mild excitements. Project Psychiatric Findings: Manneristic and stereotyped; shallow, silly, and blunted; vacuous with paucity of associations; irrelevant and scattered; mild somatic delusions, some paranoid ideation and auditory hallucinations, high degree of deterioration. Prognosis with Lobotomy: 4. On the project ward pt continued dull, vacuous, illogical, and inappropriate, with occasional periods of disturbance in which he refused to eat, became seclusive, idle, and irritable. Operation: Transorbital lobotomy, 10/28/48. The first few weeks after operation pt showed extreme dullness, gross disorientation, extreme impairment of contact, and inability to perform simple calculations. In December, 1948, he improved to a rating of 3 because of better emotional contact and integration. In January, 1949, improvement rating dropped to 4. In June, 1949, again back to his preoperative status, being extremely preoccupied and self-absorbed, shallow, silly, inappropriate, vacuous, disorganized, with urinary and fecal incontinence, and having auditory hallucinations. Improvement rating—5.

PROJECT NO. MSH Schizophrenia, Hebephrenic type

A 21-year-old, single female without occupation who finished the eighth grade at the age of 15. Prepsychotic Personality: Anxious, shy, asocial with feelings of inferiority. One sister hospitalized in mental institution, diagnosis unknown. In 1941, pt was hospitalized at Marlboro State Hospital with a several-year history of terrifying visual and probably auditory hallucinations, nightmares, loose paranoid ideation with feelings of persecution; severe anxiety and agitation. Hospitalization: 11/18/41, at MSH to present with exception of an 8-month parole in 1942—43. In hospital pt was usually assaultive and destructive, swallowed foreign bodies, was impulsively suicidal, and attempted to set her hospital room on fire. ECT in 1943, 1944 (2 courses), 1947 and 1948, had no significant effect. In September, 1947, she received a classical bilateral prefrontal lobotomy which may have reduced her anxiety temporarily, but did

point of view are those which are acute, confused, and of unclear diagnosis. If the psychologic and psychiatric investigations are to be substantial and display vigor they should be conducted upon patients who are relatively intelligent, well preserved, and cooperative so that the reports secured can be utilized with a minimum of intrusion of the personal ideas and hypotheses of the investigator. The problems involved in collecting a group of psychiatric patients who are similar enough to justify consideration as a group must be weighed in view of the circumstances obtaining at the time the work is undertaken and with an eye to the object of the study.

In connection with the question of uniformity and comparability the device of using matched pairs of patients one of whom will constitute a "control" for the other raises an exceedingly troublesome consideration. It is obvious that no 2 humans are really equivalent. Even when group averages are compared it may often be debatable whether the control and experimental groups are comparable. Another device for circumventing this problem is to consider each individual "his own control." If the tests or measures are not too subject to the effect of practice this is a way through but if the test procedure is markedly affected by learning then the method has limitations; nor can the method be used to compare 2 therapies or procedures. The question of "controls" in psychiatric research is one that demands more consideration than has hitherto been applied.

The existence of something less than ideal conditions need not interfere with the fruitfulness of "combined-operations" research but the critical question which must be answered is whether the conditions which exist render the data being gathered without value or seriously impair their value. To that end one must be constantly on the alert to make certain that no unsuspected limiting or conditioning factor has crept into the machinery of discharge of the work. In brief, it is no problem to draw up on paper the philosophy of an ideal research—the real problems arise when practical necessities force departures from the ideal.

Neither this nor our previous study made much progress in developing reliable objective methods for evaluating psychosurgical results. Indeed with a clearer definition of the common obstacles to such evaluation, it has become increasingly apparent that new objective methods are greatly needed for estimating the efficiency of any form of psychiatric therapy. Among the major obstacles to arriving at a reliable estimate of who has improved after psychosurgery are: (1) Failure and/or inability to separate changes found in the patients into effects due to the surgical procedure itself and those caused by factors merely associated with the operative procedure (as for example, total push, manipulation of the patient's environment, or simple re-evaluation of the patient's status as the result of additional study). (2) The unsatisfactory nature of the basic data related to rates of improvement without specific therapy. (3) Absence of clear agreement as to that which constitutes improvement and to what degree it is present.

Chapter 16

CONCLUSIONS

Fred A. Mettler and Carney Landis

Before proceeding to consideration of particular findings, certain generalities concerning methodology may be examined. That the "combined-operations" procedure developed for the first Columbia-Greystone project represented a progressive step in the evolution of medical, and particularly psychiatric, research is suggested by the adoption of a very similar protocol by the Group for the Advancement of Psychiatry ('48) as a theoretical ideal for research in this field. Actual project experience has revealed that certain tests and procedures planned in our original protocol and included in that of the GAP were irrelevant and should be dropped or needed modification. It is now clear that research of this sort is best conducted in a very large institution with a large bed-capacity and adequate physical space. It is also necessary to draw up a protocol which considers the limitations which time imposes upon activities and the possibilities of inter-activity interference. In practice the character of a combined-operations project is determined by necessity. Whether a combined-operations project gets done at all frequently depends upon the willingness of the group to compromise with theoretical ideals. It is easy enough to affirm that a particular list of criteria should be met by all the patients in a project but from a practical point of view one is limited by the material available at a particular moment. Furthermore, in the effort to achieve uniformity and standardization there is always the danger (which is difficult to anticipate and hard to perceive until it is too late to rectify) that one or more of the criteria set up for the sake of uniformity may preclude the possibility of change in some one of the variables which it is the object of the investigation to study.

The question might be raised for example, whether it is possible to obtain a large number of relatively "uniform" schizophrenic patients of clear diagnosis unless one is willing to descend to the level of vegetative mental deterioration which will, of course, provide greater certainty of diagnosis and uniformity of behavior but will render the group relatively inaccessible and unrepresentative for most psychologic testing and psychiatric evaluation. One must always recall that in this field it is necessary to compromise between such variables as cooperative attitude toward testing and investigation, clear diagnosis, and suitability for intensive medical and physiologic study. Often the cases which seem most desirable from an "intuitive"

the patients were seen by a psychiatrist after the use of the therapy in order to evaluate its effectiveness (Kolb '49, '50). Indeed Kolb found but 4 (excluding the first Columbia-Greystone) which satisfied his criteria, namely those of Langfelt ('37), Malamud and Render ('39), Rupp and Fletcher ('40), and Mayer-Gross ('48). Undoubtedly the difficulty of gathering such data is largely responsible for the lack of necessary information but it must also be recognized that the existence of preconceptions and the adoption of a dogmatic attitude on the part of some psychiatrists tend to create the impression that those who do gather necessary basic data are wasting their time. Progress is consequently blocked at its first necessary step. Traditionally the training of psychiatrists has emphasized the uniqueness of the individual patient. While laudable in itself this approach may have the effect of avoiding or even rejecting systematic observation of group similarities and differences which must be elucidated in order to establish a scientific foundation for categorization, as this has led to the development of general laws elsewhere in the medical sciences.

None of the above comments on methodology is new or original. We have restated them, however, because we wish to point out that positive results are not necessarily achieved in psychiatric research by the use of instruments and methods capable of a high degree of accuracy. When, as in the first Columbia-Greystone project and in the present, a large mass of negative data is accumulated it is necessary to know whether a common-sense methodology has been followed. If it has we may, taking due cognizance of the fact that nature answers only those questions put to her, conclude that the answers to the questions which the research formulated are truly negative. Careful planning, high motivation, ample funds, sincere cooperation, a real problem, and an energetic attack cannot produce positive data when the correct data are of a negative nature.

MATERIAL

The present study involved 4 different operative procedures not previously studied by us, 12 venous ligations, 2 thermocoagulations, 9 transorbital lobotomies, and 2 thalamotomies, with 2 topectomies after previous operations and 6 control subjects. None of these operative procedures is recommended for therapeutic purposes in the form in which it was utilized on cases of the type described here but certain additional basic data have been accumulated.

ANATOMIC DATA

Venous ligation is clearly a procedure capable of producing definite structural and physiologic changes. Case 38 in our first project cannot therefore be regarded as being of the nature of a control, as was suggested by some observers at the time.

(4) The effects of the disappearance of the psychoses, per se. (5) The difficulty in expressing in a concise objective manner the precise status of individual patients with regard to their past status and that of other patients.

The fifth obstacle involves not merely difficulty in stating the facts but also involves the phenomenon of variability. The usual methods which attempt to objectify the condition of patients are one or another variety of rating scale. However, since many of the important and characteristic symptoms of most psychotic patients are quantitatively and qualitatively variable, if rating scales are employed to provide the information desired, some methods will have to be developed to anchor these in standard fashions which will indicate not only the nature of the variables but also the characteristics of changes shown by the variables as well as their relationships to other significant variables. It is not too much to say that today there is no agreement as to which variables (symptoms, characteristics, changes) are important and which are unimportant.

The stubborn and persistent manner in which unduly wide variability appears in the preoperative as well as postoperative raw data of practically all disciplines would appear to indicate that something more than ordinary intraindividual variation may be interfering with analysis of the results. Indeed the manner in which variability broadens baselines is evidence that psychiatric diagnostic categories and other units of classification commonly employed are impure complexes. Ordinarily the distribution between the extremes of spread encountered for physiologic data gathered from very large samples of normal humans assumes some regularly shaped curve. While there is no distinct evidence from our work that such data gathered from psychotic individuals fall outside normal ranges there is a tendency for the distribution curves to be abnormally flattened or skewed and, occasionally, to present irregularities which may be obscure peaks. It would be necessary to analyze much larger masses of data than are thus far available before one could draw any definite conclusions about such a matter but the possibility at least exists that one reason for the persistently negative nature of most of our physiologic and psychologic investigations may be that the method of dividing the material to be studied into categories may be obstructing analysis. In any event, since the continued expenditure of time and effort along conventional lines is not likely to be any more profitable in the future than in the past some effort should at least be made to look for different ways to establish categories to be studied. For example, it might be profitable to group psychiatric patients on the basis of their response to some physiologic or psychologic tests or configurations of these or to employ statistical analysis of rating scales.

To the obstacles to evaluating the effects of psychiatric therapy we must add still another—the failure of psychiatrists to gather the necessary data. There have been surprisingly few published psychiatric studies on the efficacy of custodial therapy for schizophrenia in which

the patients were seen by a psychiatrist after the use of the therapy in order to evaluate its effectiveness (Kolb '49, '50). Indeed Kolb found but 4 (excluding the first Columbia-Greystone) which satisfied his criteria, namely those of Langfelt ('37), Malamud and Render ('39), Rupp and Fletcher ('40), and Mayer-Gross ('48). Undoubtedly the difficulty of gathering such data is largely responsible for the lack of necessary information but it must also be recognized that the existence of preconceptions and the adoption of a dogmatic attitude on the part of some psychiatrists tend to create the impression that those who do gather necessary basic data are wasting their time. Progress is consequently blocked at its first necessary step. Traditionally the training of psychiatrists has emphasized the uniqueness of the individual patient. While laudable in itself this approach may have the effect of avoiding or even rejecting systematic observation of group similarities and differences which must be elucidated in order to establish a scientific foundation for categorization, as this has led to the development of general laws elsewhere in the medical sciences.

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Although venous ligation may be carried out without untoward results such a procedure may result in scattered subcortical intracerebral hemorrhage extensive enough to coalesce and result in death. Such hemorrhage has the effect of disconnecting a certain amount of cortex and may precipitate transitory physical signs of neurologic involvement and convulsions. There is, however, no evidence to indicate that such subcortical pathology particularly predisposes the individual to seizures after the immediate postoperative period has passed. The procedure can be regarded as rendering a considerable portion of the dorsally situated granular frontal cortex nonfunctional. It should therefore precipitate changes of the same nature as are produced by removal of such cortex whatever such changes may be.

Thermocoagulation would appear to be less productive of unwanted tissue changes than either lobotomy or topectomy. There is little evidence of involvement beyond the lesion produced and there is no evidence that the procedure is unsafe or leads to convulsions.

PHYSIOLOGIC DATA

There was no clear evidence even after due allowance has been made for what has been said above with regard to widened baselines, that the psychotic individuals under investigation displayed any notable deviations from the range of normality in the physiology of their sensory, motor, or autonomic systems except that the lymphocytopenia normally observed in response to glucose tolerance tests was absent.

Among the physiologic functions studied no permanent alterations were observed after any of the procedures except thalamotomy which, as performed in the present instances, left a residual facial weakness in case B13.

In the immediate postoperative period transitory alterations were observed in a variety of functions. These changes require to be particularized and the reader is referred to Chapters 4, 5, and 6 with regard to them. In the previous project it was pointed out that a preoperative trend toward increase in weight offered a clue to the explanation of why some cases have been described as having increases in weight following operation (Freeman and Watts, '42, see p. 29). In the present cases there were no significant changes in weight or menstrual cycles and neither in this nor the previous project was there any evidence that a postoperative gain in weight is directly correlated with improvement or a loss with failure to improve.

Pool, Heath, and Weber ('49) have reported reduction in blood pressure in hypertensives and temporary improvement in the peripheral circulation after topectomy. Apart from reduction in blood pressure during bed rest no significant changes were encountered in the previous project. In the present instance the minor postoperative fluctuations which occurred in blood pressure had disappeared by the third month. "One patient (B7) showed persistent hyperten

after venous ligation." There were no significant changes in circulation time "except after thalamotomy when the patients were bedridden, hemiplegic and probably had a slow reaction time."

In the preceding project a reduction was noticed in the distance required between points for their recognition as distinct. The caution was made at that time that the phenomenon might be due to learning rather than to a genuine reduction in sensory threshold. In the present study, with repeated preoperative testing, no such phenomenon was observed after operation.

Previously the only evidence we observed of changes in the formed elements of the blood, which changes were not clearly the effect of hemorrhage, was a reticulocytosis. In the present studies the reticulocyte response was suppressed. (In subsequent studies of ablations reticulocytosis was again observed so that the immediate explanation for such a suppression is not clear.) There was no notable change in leucocytes, such as one might expect to be related to the absorption of traumatized tissue but there was a rise in the sedimentation rate.

Autonomic tests in all the present cases (there was no correlation with the type of operation performed) suggested "hyperreaction to the direct autonomic effector stimulus of epinephrine and mecholyl." Such hyperreaction had disappeared within 2 months after operation. "The postoperative cold pressor tests showed a tendency toward diminution of response."

In the preceding project it was observed "If removal of the areas ablated in these studies exerts any influence upon fasting, blood reducing substances the influence would appear to be nonspecific for areas and in the direction of a temporarily increased (for about two weeks) level of such substances. Data from glucose tolerance tests suggest that ablation of granular but not agranular cortex tends to impair the patient's ability to tolerate sugar for about a month after operation. Removal of the orbital surface does not invariably produce such a result. There is some evidence that ablation of the frontal cortex may produce a temporary increase in the blood sugar response to epinephrine but that this falls below preoperative values within three months."

In the present studies glucose tolerance tests were within normal ranges both pre- and postoperatively except following thermocoagulation after which there was a tendency toward prolonged hyperglycemia after 2 weeks and a high peak rise after the first month.

In the preceding project there was an indication that removal of granular frontal cortex resulted in an increase in the nystagmic response to rotational or caloric stimulation of the labyrinth (there was no definite correlation between the area removed and this result). The present project confirmed the opinion that such cortex exerts an inhibitory function upon the vestibular response. This influence is more pronounced upon the optokinetic type of nystagmus produced by rotation of the visual field than upon the postrotational type. Present studies also indicate that the granular frontal cortex exercises a modifying influence upon autokinetic stimulation. The data suggest that

deep, caudally placed lesions such as are produced by lobotomy abolish the reaction to the sensation while more superficially and rostrally located ones, such as those produced by topectomy, thermocoagulation, or transorbital lobotomy tend to increase reaction to the sensation.

The physiologic information to be derived from the 2 special cases (A8 and MSH) is brief. So far as we have been able to determine, removal of frontal cortex following lobotomy (in other words, of cortex connected with the rest of the brain by association fibers only) exerts no perceptible influence. Enlargement of a previous ablation (such as was done in case A8) was also relatively without effect upon physiologic function.

It is unfortunate, in the case of the transitory aphasia developed by case A10, that we are unable to specify the nature of the lesion since this case had a "radical" transorbital lobotomy. It is not implied that the bizarre phenomena described are necessarily related to that operation. There is no evidence that "ordinary" or "routine" transorbital lobotomy produces any physiologic alterations. Olfaction is not interfered with by such a procedure.

The present data tend to confirm the general findings of the previous project in which it was pointed out that the physiologic effects of granular frontal cortical removal were qualitatively and quantitatively less extensive than the literature would lead one to suppose. No correlation was developed between any physiologic alteration and "improvement."

PSYCHOLOGIC DATA

The finding of no permanent loss in intelligence resulting from psychosurgery of these varieties has been confirmed. Indeed the puzzling question at the present instant is why nonspecific injury, such as gunshot wounds, pathology of the frontal lobes (neoplasms) or translateral frontal lobotomy (involving the agranular cortex) is frequently attended by a permanent loss of some part of intellectual efficiency as evidenced by intelligence tests. No simple or apparent explanation of this discrepancy is available.

In similar fashion we have no explanation for the fact that these operations, like those of the first project, failed to influence the "categorical attitude." Certainly Goldstein's ('39) findings have been amply confirmed with frontal lobe tumor and head injury cases, but this phenomenon simply did not occur in either of our projects.

The indications from the Homograph test which led to the conclusion that such compensation in mental function as does take place is shown clearest in the postoperative recovery period and that by 3 months after operation there is clear resumption-of-function and very little or no compensation, is of more than theoretical importance. This finding indicates that rehabilitation after brain injury resulting in loss or interference with function, can best be accomplished by striving for resumption rather than compensation.

The transient changes, with consequent resumption of preoperative level of function in all tests of memory and of learning are suggestive. Could it be that the brain-injured patients who have hitherto supplied the evidence of losses of this sort were either inadequately examined or so poorly motivated that such apparent losses were found and that such "losses" constitute the basis for the textbook descriptions of the frontal lobe syndrome?

We mentioned above that some variety of rating scale seemed the most hopeful method of quantifying the improvement or lack of improvement shown by psychiatric patients. This should be modified by calling attention to the methods of Attitude Evaluation and Time-sampling observation study devised and used in this project. Neither are as yet beyond the preliminary development level but they constitute methods which can be quantified and subjected to repeated measurement. Both are improvements on most rating scale methods and deserve vigorous and critical use and further evaluation.

Insofar as the findings of the psychologic discipline may be generalized we are justified in stating that all changes resulting from the surgery used in this project were nonspecific and transitory. Neither the topectomies of the first project nor the procedures used in this project resulted in any specific variety of persistent change. There is a tendency for operations involving the agranular cortex or its major connections to bring about more marked immediate changes and in some instances these changes may persist as permanent losses. We can only use general terms to characterize these losses; flattening of affect, lowered motivation, less preoccupation with the consequences of one's words or acts, increased slovenliness, and so on.

To repeat in different words these same points we can say that all of the psychologic evidence from both this and the first Columbia-Greystone project indicates that the psychologic changes brought about by psychosurgery are non-specific. Every patient who underwent surgery showed both increases and decreases in efficiency of performance on one or more of the battery of tasks and devices which the psychologists used. The changes, either increases or decreases, were not systematically related to the area excised, the blood supply interfered with, or the neural mechanisms severed. The changes were most clearly demonstrable during the first postoperative month and usually disappeared by 3 months following operation. Since they disappear we have termed them transient and since they immediately follow and are closely associated with the operation we believe that they are in some fashion connected with the surgery.

It does happen that an occasional patient immediately after operation shows a loss in the "psychic pain" of mental illness, but in most, the amelioration occurs somewhat more slowly, while in some it is not apparent for 6 months or more. The immediate loss of psychic pain might be held to indicate that the operation itself amputated—so to speak—the psychosis, while the protracted recovery would argue that loss was secondary to the operation and probably should be related to some phase of the healing process.

PSYCHIATRIC DATA

In the cases under study in this project little alteration was observed prior to operation. The psychiatric discipline used "Sodium Amytal interviews—as an auxiliary to the clinical appraisal of the patient." It is stated that "In all patients who remained unchanged or only slightly improved under Amytal the operation did not lead to improvement." It has been concluded "that if a deteriorated patient did not show any remission of his symptoms under Sodium Amytal there is little prospect that the operative procedure of this study would improve his condition." Examination of figure 54, however, discloses that of the 4 operated patients who were rated by the psychiatric discipline as improved to some degree a year later not one had given any significant response to Amytal preoperatively. Furthermore not one of the 11 patients who did show any response to Amytal preoperatively are reported as showing any improvement after operation. It must be conceded that the conclusion of the psychiatric discipline as to the prognostic value of Amytal interviews is quite unsupported by the actual data included in the report of that discipline. Furthermore it is at variance with another conclusion of that discipline appearing under the heading of Results, Venous Ligation notably "There is no evidence of correlation between the slight improvement observed and the diagnosis, duration of illness, previous shock therapy, response to Sodium Amytal, oscillations in clinical course, place of ligation, or presence of transient but severe neurological signs."

It may be added that the data in this instance fail to show any close correlation between degree of deterioration or preoperative prognostic rating and postoperative improvement. This has not been the case in previous or subsequent work.

COMPARISON OF RATE OF RELEASE FROM THE HOSPITAL IN THIS AND OTHER PROJECTS

Examination of and comparison between the results of this and other Columbia-Greystone projects on November 10, 1950 disclosed the following figures:

CGI controls out of hospital (that is, in the community) without surgery, 4 of 16. (No change as of 6/27/51)

CGI controls out of hospital following subsequent lobotomy, 3 of 8. (2 of 8, as of 6/27/51)

CGI topectomies out of hospital without subsequent surgery, 11 of 23 (one additional case, A19, died of pneumonia contracted outside the hospital, having been out for over a year) (10 of 23 as of 6/27/51)

CGI topectomies out of hospital following subsequent lobotomy, 0 of 2

CGI venous ligation now out of hospital without subsequent surgery, 1 of 1

CGII controls out of hospital without surgery, 1 of 6

CGII venous ligations out of hospital without subsequent surgery, 2 of 11

CGII venous ligations out of hospital following subsequent surgery. Not done

CGII transorbital lobotomies out of hospital, 0 of 9

Therapeutic Series. Transorbital lobotomies, from Greystone therapeutic series, out of hospital without subsequent surgery, 27 of 80.

It may be categorically stated that unless one is dealing with committed patients who have been institutionalized for at least 2 years it is difficult or impossible to decide whether alteration in the status of any group of patients subjected to a particular psychiatric therapy is causally related to the "apparently active elements" in such therapy. A certain proportion of the discharges which occur among institutionalized patients who pass through the psychosurgical routine is assuredly quite unrelated to the actual operative procedure (Mettler, '49) and the number of such cases will obviously be larger (and the spurious benefit attributed to psychosurgery correspondingly greater) if one operates upon cases who have not been institutionalized for that length of time.

On the other hand it is possible to select patients who either because of psychiatric state or disintegration of their social status offer little prospect of movement out of their institution. According to Heath, Weber, and Crandell ('49) the absence of "painful" affect or presence of an advanced dissociation between affect and ideation disclose a psychiatric state unfavorable for operation. An effort to examine into possible mechanisms by which psychosurgery might operate is made farther along but for the present it may be said, as Heath et al. have pointed out, that it is not easy to determine from mere records whether patients lack painful affect or to what extent affect and ideation are dissociated. Another method of arriving at an opinion as to whether the expectation for one group is better or worse than for another (this method has no value for individual patients), is to compare the relative length of the time of uninterrupted institutionalization in the 2 groups. Comparable objective data of this nature can be obtained by dividing the sum of the months all patients in a group have been institutionalized by the sum of the number of all interruptions occurring in the records of institutionalization of all members of that group. The magnitude of this figure to which we have applied the term "occlusive index," and which reflects in a general but standard manner the duration in months of uninterrupted institutionalization for the group, can be considered to be the sum of a variety of factors which practically oppose the patient's return to the community. Thus if the interruptions are more numerous in one group than in another, institutionalized for the same or a longer period of time, the former group may be expected to have a greater number of returns to the community

than the latter since the preoperative pattern tends to repeat itself in the postoperative period. Attention is again called to the fact that comparison of the magnitude of this figure for different groups of cases has the advantage of simultaneously reflecting occlusive factors in the patient's environment as well as the degree of inertia of the psychiatric disability.

In Project A, in which there were 24 operated patients, there were 41 interruptions in 1310 months of aggregate institutionalization, a standard duration of uninterrupted institutionalization of 31.9 months.

In Project B, 11 patients survived venous ligation. These had a total of 13 interruptions in 757 months of institutionalization (a standard duration of uninterrupted institutionalization of 58.2 months). It is interesting to observe that not only does the rate of discharge fall off rapidly as the period of uninterrupted institutionalization increases (18.1 per cent as compared with 45.8) but also that both the rate of discharge for the unoperated controls in the first Greystone series (25 per cent) and standard duration of uninterrupted institutionalization (54.5 months) lie between the figures for the 2 groups just considered (fig. 56).

It is probable that the value of this method of forecasting group results could be improved by taking into consideration not merely the number of times the patient has left the hospital but also the actual number of months he has spent outside since his original commitment and perhaps the number of patients in the group should be given more explicit representation in the final figure. The number of cases in our own projects is not large enough to encourage extension of the technique by us at the moment but it is probable that psychiatric material other than psychosurgical could be employed in such an investigation. It is also likely, as has been suggested by Professor Zubin, that some method could be worked out to dissociate the social service factors from those involving inertia of the patient's disability. Since the rate of recovery of the control patients shown in figure 56 is higher than that of the venous ligations and since topectomy has thus far failed to result in return to the community of any significant number of the patients in the C and D groups at Rockland (who have quite long standard durations of uninterrupted institutionalization, 83 months for the D and 295.6 months for the C groups) one is forced to conclude that the opportunity for discharge following psychosurgery is more closely related to factors governing the course of the disease during the preoperative period than it is to the operation itself. Such a consideration leads us to inquire within what limits psychosurgery exerts its influence if indeed it exerts any influence at all.

WHAT INFLUENCE DOES PSYCHOSURGERY EXERT?

A distinction between forms of psychosurgery is necessary insofar as the operation does or does not infringe upon mechanisms which are

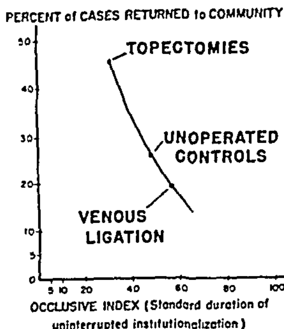


FIG. 56. Relation of rate of returns to the community to the duration of uninterrupted institutionalization computed for 3 groups of Greystone cases in terms of "standard duration of uninterrupted institutionalization." This is the sum of the number of months all patients of the group were institutionalized, divided by the number of interruptions in total group. In order to count as such, an "interruption" must represent a situation in which the patient's emergence from the hospital is made in the expectation that he will stay out if he is able to so do. For the operated cases in the C and D groups shown in Fig. 3 the "occlusive index" (standard durations of uninterrupted institutionalization) were 295,6 and 83 months respectively.

primarily related with the granular frontal cortex. Bilateral ablation of agranular frontal cortex produces very marked changes in the behavior of a primate as contrasted to what occurs after bilateral removal of granular frontal cortex (Mettler, '44). In the early days of psychosurgery in the United States, when radical psychosurgery was more common than it is at present, alteration in the condition of the patient was evident commonly enough to result in the widespread impression that lobotomy produced serious deterioration. As a result of such adverse criticism practitioners of psychosurgery were forced to restrict the operative procedure to more rostral areas. In spite of such restriction it was still possible to report an appreciable proportion of cases as showing postoperative improvement. Although in topectomy the amount of tissue removed from both sides of the brain has been reduced to less than 12 grams (case 19, Columbia Greystone Associates, '49) in a seriously ill schizophrenic (14 years' duration, the last 7 institutionalized) this man was able to return to his family and community following this operation.

We have now completed several psychosurgical projects without having been able to demonstrate that interference with the granular frontal cortex or its associated mechanisms produces any effect the duration or occurrence of which is related with the patient's "improvement." A possible exception to this exists in the reduction in anxiety

than the latter since the preoperative pattern tends to repeat itself in the postoperative period. Attention is again called to the fact that comparison of the magnitude of this figure for different groups of cases has the advantage of simultaneously reflecting occlusive factors in the patient's environment as well as the degree of inertia of the psychiatric disability.

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results. Even though the results of prefrontal leucotomy are superior to the ones of parietal leucotomy the latter seemed to have some value in the treatment of psychosis." We interpret this statement of Yahn's to mean that 2 out of his operated group of schizophrenic patients recovered following parietal lobotomy, and hence are further evidence that it is not necessary to sever the fronto-thalamic tracts in order to bring about recovery.

Another hypothesis has been constructed around the relationship existing between the apparent deterioration or malignancy of psychosis of the patient before the operation and his chances of ultimate recovery following psychosurgery. The general assumption has been that the patients showing the least malignancy or deterioration were those having the best chances of recovery. The report of Heath, Weber, and Crandell ('49) in the first Columbia-Greystone project, and the psychiatric report in the present project, both indicate that while there is some relationship between psychiatric ratings and the outcome the correlation is far from perfect. If duration of hospitalization alone and outcome are compared, only a low correlation is apparent in both studies. This correlation is considerably improved, as has been indicated above, if the "occlusive index" is taken into consideration. Further it may be seriously doubted whether any reliable quantitative measure of "deterioration" exists.

Although no final evidence is at hand to prove the point, the review of the psychologic test results which were obtained before psychosurgery was carried out, does seem to indicate that those test performances which showed signs of confusion were those which were associated with improvement or recovery from psychosis following psychosurgery. In an analysis of the Porteus Maze test Landis and Erlick ('50) present certain evidence relevant to this particular point. Further evidence of the same sort has been found by Zubin and Windle ('50) in their analysis of the Homograph test.

A difficult question to answer if one holds to any theory of specificity (specificity of tracts, cortical areas, diagnosis, personality type, or symptom picture) and outcome is why certain psychosurgery patients who recover following operation, continue in their non-psychotic state for a period of months and then relapse. When relapse occurs such patients show the same psychotic symptomatic picture that was presented before the operation. That is, whatever specificity in symptoms of disease existed was not altered by the operation.

Finally, the loss of the anguish of intractable pain in certain—though not in all—lobotomy cases, must be considered. These patients do not lose any cutaneous sensibility, indeed some of them report that the pain from which they have been suffering has not been extinguished but that its quality is now such that it can be disregarded in somewhat the same fashion that the hallucinated patient sometimes reports that lobotomy lowered the insistence and volume of his "voices" so that they no longer demand his attention. It is customary to regard the anguish in intractable pain as "real," in that it has a basis in actual

which most "improved" patients exhibit but, of course, it is by no means certain that such a reduction in anxiety is a peculiar result of the operative procedure. Although it cannot be said that we have demonstrated that psychosurgery produces any particular effect it may be worth examining certain hypotheses about how psychosurgery might produce "improvement" if it does. It should be emphasized that the next few paragraphs are of a completely speculative nature.

A number of investigators have advanced the idea that amelioration from psychosis is a quantitative affair. They point out that many persons of schizoid personality become schizophrenic and that the psychosis is to be regarded as but a quantitative exaggeration of the basic personality. After operation such patients, they say, show a reduction in schizophrenia, returning to their prepsychotic schizoid personality. This, they regard a quantitative reduction without change in basic personality structure. From the information supplied by social service and by psychiatry we judge that this theory would hold in the instance of 2 operated patients (venous ligation) who were somewhat improved following the surgery done in the present project. That serious objections exist against this explanation was indicated by the progress reports of several patients who were studied in the first Columbia-Greystone project and who recovered from psychosis. Two patients in particular, both hebephrenic dementia praecox, one having had a lobotomy and one a topectomy were reported by social service and by the hospital psychiatrists to be of such changed personality that it was justified to consider that a qualitative difference in personality had resulted from the operation. The review of the Rorschach personality sketches which Zubin ('49) reported in the first Columbia-Greystone project also indicated that some patients were essentially unchanged in personality structure following operation while others showed a rather definite change. Such phenomena were, however, encountered in control as well as operated cases. Whether psychosurgery changes personality remains a debatable point, but certainly it is not established that changes are entirely quantitative and never qualitative or that operation is the responsible factor.

The fact that lateral transcranial lobotomy severs the fronto-thalamic connections has been repeatedly cited as evidence that cutting this specific system, rather than cortical removal, is necessary for a successful therapeutic outcome following psychosurgery. Certainly both the venous ligation operations and the area 11 topectomies, which have in some instances been followed by undoubted amelioration from psychosis are clear evidence that such specificity need not obtain. The report of Yahn, et al., ('48) of 22 cases of parietal lobotomy casts further doubt on the hypothesis of the specificity of action of severance of the fronto-thalamic projection system. Yahn reported as follows, "Twenty-two patients were operated upon; 19 chronic schizophrenics.... Only two cases with chronic schizophrenia improved. The validity of the method could not be fully appreciated because in all cases other methods of treatment were tried; in 17 a prefrontal leucotomy gave no

mental changes following psychosurgery hold if it is accepted that the operation decreases in an unspecific fashion, either peripheral attention, or the particular phenomenological attribute of feeling of familiarity. Variability in the transient postoperative changes may be the result of selective inattention or the lack of familiarity or may be the result of individual variability in the manner in which the frontal cortex is utilized in the cerebral activity of different individuals (Wittenborn and Mettler, '51). If the patient loses his psychic pain or psychosis he may remark that the "voices," the "ideas," are somehow detached from him. They can now be neglected, although if he thinks about them they are still available. The patient with intractable pain likewise becomes less bound to or familiar with his pain following operation.

We have consistently found in both the physiologic and psychologic studies a lack of specificity between the surgery done and the changes resulting. We have emphasized this lack of consistency in results and have argued that it does not fit in with most of the commonly advanced theories which purport to explain or rationalize the changes sometimes observed or only temporarily encountered following psychosurgery. Both hypotheses which we have advanced are speculative but neither does violence to any systematic observations of which we are aware.

physical pathology, while hallucinations are considered "unreal," in that no known physical basis exists. Perhaps psychosurgery in some way disconnects, wholly or partly, the mental bond existing between different orders of mental processes which may be either "real" or "unreal" in basis.

These considerations may be summarized as follows: Most psychologic changes are transient and related to the operation. The loss in anguish associated with either psychic or physical pain is somehow a resultant mental disconnection produced by the operation. The amelioration from the anguish may be a quantitative affair but in some instances it seems qualitative rather than quantitative. The amelioration is not as closely related to preoperative mental deterioration as it is to mental confusion. Can these conclusions be brought together in terms of a more reasonable hypothesis?

Two alternative hypotheses suggest themselves. (1) Psychosurgery of the frontal lobes results in a narrowing of the field of attention so that there is tendency for the patient to be stimulus-bound. (2) Surgery adds to the mental confusion of the patient. This confusion grows out of an interference with the associative bonds linking mental elements *and is usually reported as a loss or decrease in the feeling of familiarity* or increase in the feeling of unreality.

Mettler ('44) ('49b) pointed out that a leading symptom in lobectomized primates and in topectomized humans was a tendency to be governed by the immediate field of stimulation, particularly that portion of the field which had the highest attention-gaining value. Halstead ('47) has also emphasized "stimulus-binding" after brain injuries. Peripheral stimuli which should be cues to more adequate or correct response are neglected. In these terms the changes after psychosurgery are to be conceived of as an overresponsiveness to immediate sense impression and a diminution of the affect of those mental elements coming from past experience. In this fashion the loss in self-conscious anxiety, the forthright, bluntly spoken remarks, the lack of foresight and loss in the anguish of intractable pain, become reasonable.

Landis and Bolles ('50) have developed the idea that the loss of familiarity shown so clearly by patients following electrical convulsive therapy can be extended to cover the general phenomena of amnesia and aphasia. Essentially the theory holds that the feeling of familiarity is the associative bond holding the mental elements of memory and experience together. Electrical convulsive therapy, head injury, and the like, act to break or weaken these bonds so that the conscious life becomes confused. Elements can be recognized but the feeling of familiarity is defective. Such patients are not sure how the facts, the elements of memory, experience, and of reality, fit together. It is as if the associations had weakened so that the ideas are no longer connected as they were in the past or as they should be in normal mental life (Landis, Zubin and Mettler, '50).

Either of these 2 hypotheses which we advance with respect to the

or groups of patients in the same order in which they were given in the original report and the comparative findings will then be discussed.

PATIENTS WHO HAD CHANGED WITHOUT OPERATION WHEN REPORTED AT THE END OF ONE YEAR

PATIENT NO. 9. This patient was returned to Greystone in February, 1948 and made some improvement following electro-shock therapy (December, 1948). He was defensive and rather expansive when seen by the social worker in February, 1949, however, and he was still hospitalized at the end of the 2-year follow-up period.

PATIENT NO. 15. Following parole in October, 1947, this man lived at a club camp until he moved to the city branch of the club. According to the social worker's note of March, 1949, the authorities of the camp indicated that the patient left because "people were prying into his affairs," but the patient insisted he left for financial reasons. He worked as a button cutter until the factory closed in May, 1948 and thereafter as a porter in the club where he lived. When seen by the psychiatrist in September, 1949, he appeared to be making an adequate adjustment, without obvious psychopathology although he remained a stolid, passive, and dependent individual.

PATIENT NO. 34. This woman was discharged from the hospital in July, 1947 and began working as a part-time salesgirl in a department store in November, 1947. She worked her way into a full-time job which she continued to hold when seen by the psychiatrist in July, 1949. She made a good social and vocational adjustment, gained weight, slept well, and acquired a boyfriend though she stated she was not seriously interested in marriage. At the time of interview she was living with her mother with whom she made a good adjustment. In spite of several deaths in the family, the patient continued to function well without obvious psychopathology and this was corroborated by the social worker's visit to her home in April, 1949.

PATIENT NO. 39. Following her parole in January, 1948 this woman worked part-time in a bakery until April, 1949 but was discharged after she complained that she had not received the customary vacation bonus. She expected to return to work in September, feeling under no pressure to look for work, since she has her own income. When seen in July, 1949 she presented much the same picture that she had one year before. She was superficially pleasant but caustic and critical of other people and referred frequently to her concern about her own security. She often expressed a desire to have another husband although she said she had no sexual desires. She was fearful of a recurrence of illness, however, and this was also brought out during the social worker's visit in April, 1949.

CONTROL PATIENTS WHO HAD NOT IMPROVED AT THE END OF THE ONE-YEAR PERIOD

PATIENT NO. 1. When seen by the psychiatrist in December, 1948, and by the social worker in February, 1949 the patient was pleasant, cooperative and was working on the wards and in the hospital library. He complained of

Chapter 17

THE ORIGINAL COLUMBIA-GREYSTONE PATIENTS TWO YEARS AFTER OPERATION[11]

John J. Weber

The original Columbia-Greystone investigation was carried out in the spring and summer of 1947 and the results were reported in detail in 1949 (Columbia Greystone Associates, '49). A total of 48 patients was studied, 24 each in the original operated and non-operated groups. A variety of procedures was represented among these patients including topectomies of various areas of frontal lobe cortex, venous ligation, (patient no. 38), anaesthesia with phlebotomy (controls), and lobotomies. The latter were performed on 6 patients who had originally been non-operated controls (patients no. 5, 11, 20, 23, 28, and 46) and on 2 patients who had failed to improve after earlier removal of Brodmann's areas 6, 8, 10, and 47 (patients no. 2 and 44). (A transorbital lobotomy was performed on patient no. 26 in April, 1949 as a part of another study.) Psychiatric follow-up studies were carried out on all patients for one year after the original time of operation with the emphasis being devoted to the patient's social and vocational status, type and intensity of psychopathology after operation, evidences of undesirable changes in personality structure, and the occurrence of seizures postoperatively. A numerical grading system was devised for the original report to indicate the extent of change in the patient's social and vocational status insofar as such factors can be expressed numerically from clinical studies.

Since the report of the original study, contact has been maintained with the patients of the group. Interviews with a social service worker have been held with all patients during this time. Those patients who were outside the institution were usually seen frequently. Thirty of the 33 hospitalized patients were interviewed by the author in December 1948 and 14 of the 15 patients who were living outside of an institution were seen by him in July and September of 1949. In addition, various staff members at Greystone Park have contributed observations, and occasional letters from patients or their relatives were utilized. Throughout this period, the same orientation was made in the observation of patients as was carried out in the original project. The data obtained in this way will be reported for individual patients

11. That is, July 1949. The author wishes to express his appreciation to Dr. Archie Crandell, Dr. H. Anderson, Miss Violet G. Bemmels, Miss Jennie Berman, and other members of the Staff of the New Jersey State Hospital for their cooperation in this study.

pleased with the result of operation but found it had made him "stubborn." Psychiatrically his behavior was characterized by facetious laughter and marked unconcern about himself, denying that he had ever had any problems or that he had been operated upon, but his preoperative behavior had also been marked by an air of unconcern. Delusions and hallucinations could not be elicited.

PATIENT NO. 20. This man was returned to Greystone in September, 1948. When interviewed in December, 1948 he was indolent, preoccupied, and withdrawn. According to his parents, however, he was aggressive and critical when taken home for visits. When seen by the social worker in April, 1949, the patient had been transferred to another hospital where his behavior remained passive and preoccupied. Hospitalization was still necessary at the end of the 2-year follow-up period.

PATIENT NO. 23. When seen by the psychiatrist in December, 1948, this man was still hospitalized. He was working on ground parole, however, and was less of a management problem according to his physician who also pointed out that he "had lost all push so far as his ideas are concerned" although he still described somatic delusions and ideas of influence when asked about them. This condition was maintained at the time of the social worker's interview in February, 1949 and hospitalization was still necessary at the time of writing.

PATIENT NO. 28. This patient was seen by the psychiatrist in December, 1948 and by the social worker in March, 1949. He remained fearful, preoccupied and, at times, depressed. Operation had apparently not influenced the course of his illness in any way which could be detected.

PATIENT NO. 46. This woman was uncommunicative when interviewed by the psychiatrist and social worker and was still responding to auditory hallucinations according to the ward personnel.

PATIENTS WHO SHOWED IMPROVEMENT ONE YEAR AFTER TOPECTOMY

PATIENT NO. 4. This man continued to work as a street cleaner during his second year out of the hospital. When seen by the social worker in February and March, 1949 and by the psychiatrist in July, 1949 he repeated many of his earlier somatic complaints and sexual preoccupations but he was less agitated than he had been in previous interviews. He continued to lead a rather solitary life and depended on his family for reassurance although he was financially self-supporting.

PATIENT NO. 7. This patient was out of the hospital on visit when the psychiatrist visited in December, 1948 but reports from his ward personnel indicated that he was making a good hospital adjustment and working in the institution. His attitude toward his [illegible]
and continued to cause difficulty when
in March, 1949. At that time he insist[illegible]
wife but implied he could not consider working outside an institution because his wife did not love him. Despite much resistance on the part of the patient, a placement was arranged for him on a chicken farm where

"depression" and felt that an operation would get him out of the hospital. He did not wish to return to live with his sister, however, because he felt a "clean break" was necessary and he was still hospitalized at the time of writing.

PATIENT NO. 10. Interviews in December, 1948 and April, 1949 demonstrated no change in this patient's condition.

PATIENT NO. 12. This man improved spontaneously and was paroled from the hospital in August, 1948. He was assisted financially by his brother who supplied a house for the patient and his wife, and the patient's wife was delighted to have him home. He was not working when seen in July, 1949 but was busying himself making repairs about the house in spite of several bothersome physical complaints. Outstanding at this time was his grandiose trend with frequent use of well-known names and references to large amounts of money. There was no definite delusional system and hallucinations were denied. His judgment was poor, however, particularly about business matters. The social worker's visit made earlier in the year demonstrated the wife's great protective concern for her husband and her desire to help him.

PATIENTS NO. 14, 16, 17. There was no marked change.

PATIENT NO. 26. This patient improved with electrical shock treatment but hospitalization was still necessary in December, 1948 and March, 1949. Transorbital lobotomy was performed in April, 1949 in connection with another study.

PATIENTS NO. 29, 30, 35, 37, 41, 45, 48. There was no change at the end of 2 years.

CONTROL PATIENTS WHO WERE SUBJECTED TO LOBOTOMY

PATIENT NO. 5. When seen in July, 1949 this patient had changed dramatically in his appearance, having gained about 40 pounds in weight. His wife said he had been paroled from Greystone in June, 1948 but had not been able to find a job and was living on relief. The social worker's interview of his family in January, 1949 indicated that the family's only unfavorable comment was that he had no initiative since operation and that this was the reason for his unemployment. Psychiatric interview confirmed this impression and presented the picture of a man without obvious psychopathology except for his unconcern and lethargy. (It should be pointed out that this lack of initiative was also a feature of the patient's preoperative behavior.) His speech was slow, his affective responses shallow, and he was unconcerned about his own and his family's future.

PATIENT NO. 11. After leaving the hospital this man worked for 8 months in a dye factory and, in October, 1948, he began work as a boilerman in a public school. This was an easier job than he had held previous to his illness and he was working at a lower capacity than his earlier jobs in the silk industry had required. Interviews by the psychiatrist in July, 1949 and by the social worker in January, 1949 indicated that the family was

according to the informants he washed his hands compulsively many times a day.

PATIENT NO. 36. This patient was seen by the psychiatrist in December, 1948 and several interviews with the social worker took place between February and April, 1949. The patient was less agitated than she had been in previous interviews and was working satisfactorily in the hospital. Although she continued to hallucinate, she did not appear to react to the hallucinatory voices and did not discuss them unless questioned closely. She wished to return to her home but her grasp of the home situation was inadequate and her family was not eager to have her return so that efforts to arrange a trial period at home were unsuccessful.

PATIENT NO. 49. Following her temporary relapse at the one-year period this patient secured another job as a domestic which lasted only one month and then took a similar position in a congenial home which had worked out satisfactorily at the time she was interviewed in July, 1949. She displayed no obvious psychopathology except that she appeared emotionally somewhat flat. The patient stated that she was taking a more active interest in people and had joined a bridge club but she recognized that she was still retiring and that she would require more time to achieve social ease. The social worker interviewed the patient and her sister in February and April, 1949 and reported that her sister had taken a firm attitude with her after her breakdown in June but had continued to be helpful in her treatment of the patient.

PATIENTS REPORTED AS SHOWING TEMPORARY IMPROVEMENT ONE YEAR AFTER TOPECTOMY

PATIENT NO. 3. This patient's condition did not improve materially during the second year. He was interviewed in December, 1948 and February and March, 1949 and any changes noted were in the direction of further regression. He continued on hospital status at the end of the second year.

PATIENT NO. 27. This patient recovered from the deeply regressed state reported at the one-year follow-up and when seen by the psychologist in November, 1948 he was cooperative and generally coherent. He wished to return to college and become a teacher. Mental examination indicated, however, that he made contradictory statements about his pre- and post-operative activities and he was confused on dates and events important in his life. He complained repeatedly and perseveratively of pain in the head which he attributed to a kick. He admitted that delusions and hallucinations were present at that time. He was paroled during the month of January, 1949 and worked briefly as a shipping clerk but it was necessary to return him to the hospital. When seen by the social worker in March, 1949 his behavior was similar to that described by the psychologist.

PATIENT NO. 33. This patient was readmitted to the hospital in May, 1948 and rapidly slipped into a catatonic stupor. She died on 8/28/49, death being due to pulmonary pathology.

he began work in June, 1949, but he remained on the job only one day and was then rehospitalized.

PATIENT NO. 8. This patient had a second operation (enlargement of the original incision) on 10/20/48 but seizures continued thereafter. When he was seen by the psychiatrist in December, 1948, he was cooperative and expressed a desire to be discharged so that he might return to work but he appeared tense and was obviously projecting onto other patients. The picture remained about the same when he was seen by the social worker in April, 1949 and it has not been possible to discharge this patient.

PATIENT NO. 13. Following his parole from the hospital, this man began work as a handyman in an orphanage. He continued to make an adequate adjustment in this situation when seen by the social worker in March, 1949 and by the psychiatrist in July, 1949. He stated, however, that he "hated" his job because it separated him from his wife and family and his preoccupation with this separation remained intense. He refused to accept the fact that his wife had secured a divorce and he continued to express ideas of reference although these did not seriously interfere with his adjustment outside of an institution.

PATIENT NO. 21. This man was interviewed in March and July, 1949. He continued to work as a laboratory assistant during his second postoperative year and performed well on the job. He was querulous at times but there was a decrease noted in the number of somatic complaints which he offered. He was interested in sports and movies but had few friends. Despite many quarrels at home, he continued to live with his family and could not bring himself to live independently. There were no pronounced mood swings during the year.

PATIENT NO. 22. After leaving the hospital in July, 1948, the patient worked for 3 months in the textile mills but found the work too difficult and got a job as an upholstery stuffer. When seen in January, 1949 he was somewhat depressed and fearful that he would be returned to the hospital by the social service worker. He described morning depression when seen by the psychiatrist in July, 1949 and wept briefly as he discussed events connected with his early life. He felt much improved by operation, however, but he continued to be fearful of the future and was frightened by recurring dreams. A poorly defined paranoid trend was also elicited but he did not express delusions or hallucinations. The patient's wife stated that he usually wept only when someone new was around and that he worked, ate and slept well although he was not interested in any social life.

PATIENT NO. 25. This patient failed to keep 2 appointments made for him with the psychiatrist and was seen by the social worker in April, 1949 only after considerable difficulty. Following his release from the hospital he had obtained his former job as a newspaper mailer and he returned to his previous pattern of dependence on his family and his woman friend. His family commented that he seemed more forgetful than he was before operation and that he had frequent nightmares and complained of pains in his stomach. He remained seclusive and inconsiderate of his family, and

to leave home. His wife was pleased with his adjustment when she was interviewed in March, 1949 and stated that surgery had made him much "quieter" and life was therefore more livable with the patient.

PATIENT NO. 31. There was no fundamental change in this patient's condition although slight improvement was noted at times.

PATIENT NO. 32. This patient continued on hospital care throughout the year, her condition remaining generally as described at the end of the one-year period.

PATIENT NO. 40. Although improved as a management problem, this patient continued to be suspicious, hypercritical, and was not considered for parole.

PATIENTS No. 44, 47. These patients continued unchanged throughout the year, remaining inappropriate and incoherent in speech and obviously in poor contact with their surroundings. (A lobotomy was performed on patient no. 44 after the original topectomy.)

DISCUSSION

The social and vocational status of the operated and unoperated patients is summarized in Table 1 which gives the type of operation performed as well as the rating given each patient 7-1/2 months, 1 year, and 2 years after operation. (In the case of lobotomized controls, results are reported only at one year and 2 years, since the patients were at first followed as unoperated cases.)

At the end of 7-1/2 months, 9 patients who had removals of areas 9, 10, or 46, alone or in combination, were given social ratings above 3 points. By the end of one year, 2 of these patients relapsed (nos. 27, 33) and were returned to the hospital, where one of them died (no. 33) at the end of the second year. Another patient (no. 7) was returned to the hospital during the second postoperative year although his mental status had changed little, if at all, during that time. Six of the original 9 patients had maintained their good adjustment at the end of the 2-year follow-up.

One patient (no. 42) made a good adjustment 7-1/2 months after removal of area 11 and she continued to do well at the time of the one-year and 2-year examinations. Patient no. 4 made a somewhat improved adjustment 7-1/2 months after removal of areas 10 and 46 but improvement was more marked at the end of one and 2 years. Patient no. 19 was apparently unchanged 7-1/2 months and one year after removal of area 45 but was functioning well at the end of 2 years. The remaining topectomized patients showed little or no change during the second year, except for patients no. 2 and no. 40 who were reported to be more manageable within the institution.

PATIENTS IN WHOM IMPROVEMENT WAS QUESTIONABLY RELATED TO OPERATION IN THE ORIGINAL REPORT

PATIENT NO. 38. This patient left Greystone in September, 1947 and 2 weeks later got a job in a factory assembly line which she held until May, 1949 when the plant was put on a skeletal crew. She was apologetic when talking to the social worker of her job in January, 1949, explaining that this was a less responsible position than her former one of typist-bookkeeper but that she felt more comfortable doing it. Her mental status indicated that she had maintained her condition as described one year after operation and that very little suggestion of elevated mood remained.

PATIENT NO. 42. Following her discharge, this patient began work as cashier in a supermarket in September, 1948 and continued to do well at this job throughout the second postoperative year. When seen by the psychiatrist in July, 1949 she was cooperative, grateful for operation (in spite of seizures) and appeared to have no mood disturbance although she was somewhat tense and said she was irritable at times. The social worker's interview in February, 1949 indicated that the patient's husband was helpful though ununderstanding at times and that the patient was sometimes resentful of her stepson.

PATIENTS WHO WERE UNCHANGED ONE YEAR FOLLOWING TOPECTOMY

PATIENT NO. 2. When seen by the psychiatrist in the hospital in December, 1948 the patient was restless, vague and there was no logical progression of ideas. He described auditory hallucinations, was often incoherent, his judgment was faulty and he was only partially oriented to his surroundings. He was able to do simple jobs around the ward in spite of his condition. During the next few months his condition improved somewhat and during the month of April, 1949 the social worker attempted to work out a placement for him at home should that prove feasible later on. Until July, 1949, however, the patient had not improved sufficiently and he continued to be hospitalized, despite the lobotomy which had been performed after topectomy.

PATIENT NO. 6. There was no change in this patient's condition during the second year except for further return of motor power to his paretic arm.

PATIENT NO. 18. This patient continued to make a good hospital adjustment but had no interest in leaving the institution and resisted any suggestion of parole stating that his had to be a "gradual improvement." He worked actively in the hospital shops and showed no obvious psychopathology on examination (although auditory hallucinations were suspected by the staff physicians).

PATIENT NO. 19. This man returned to his home and to work in his candy store in October, 1948. When seen by the psychiatrist in July, 1949 he was cheerful and no delusions or hallucinations were elicited. He remembered several of his earlier escapades at home and in the hospital but said that he was no longer excited and did not feel his former urges

Table 57

DISTRIBUTION OF SEIZURES

Patient Number	No. of Seizures	Dates	Remarks
5	1	June '48	2 seizures postoperatively
6	1	Nov. '47	
8	Many		Seizures were not relieved by reoperation (Oct. 1948)
13	6	Jan. '48 - May '49	Progressively less severe
20	4	Apr. '48 - Apr. '49	
40	?4	Dec. '47 - ?Mar. '48	
42	6	Jan. '48 - Mar. '49	

tributed their recovery entirely to the interest shown them while they were on the special ward which was devoted to the project, in the type of "total push" effect which the presence of unoperated patients was designed to control. It appears too that the visits from the social worker and the continued interest of the psychiatrist were also of value to the patients as indications of continued support on the part of the institution and some of the patients appeared to derive considerable support from the feeling of belonging to this special study group. The role of the families was many times obvious in pressing for trial visits or in refusing to consider such a visit when it was recommended by the attending psychiatrist. Some idea of the possible implications may be gained from a report of the social worker who found that: "of the 10 operated patients who failed to adjust outside of the hospital, (at least 3) returned to husbands or wives who did not want them and 5 returned to parents for whom the patients felt great antagonism." She also points out that of 6 patients who failed to improve enough to leave the hospital, 2 were rejected by their wives and "the relatives of the remainder expressed antagonism or showed indifference." On the other hand, among 11 patients now outside the hospital for whom information is available (including one unoperated patient), 10 returned to families where they appeared to be wanted and where they were given help or returned to the care of agencies which attempted to assist the patient in re-establishing himself. Comparable figures on the families of the unimproved, unoperated patients would be of interest but are not available and the social worker commented that this group seemed "eager to sever all relationships with hospital." More extensive social work and psychiatric investigation are necessary to establish the importance of social and family influences as they affect psychiatric improvement in these patients and it is not now possible to

Among the 6 lobotomized control patients, one man (no. 20) had to be rehospitalized during the second year while 2 others continued to make good adjustments. The remaining 3 patients changed little or not at all after the operation. Neither of the patients who had had lobotomies following unsuccessful topectomies was able to leave the institution (patients no. 2, 44) nor was patient no. 26 who had had a transorbital lobotomy in April, 1949.

One unoperated patient (no. 9) relapsed during the second year and one other (no. 12) was able to return home. The total number of unoperated patients outside the hospital remained constant at 4 and there was little variation among the remaining control cases.

The degree of psychopathology varied among the patients, some (nos. 21, 38, 42, 49) showing little on examination while others seemed to make their adjustment satisfactorily in spite of rather marked pathology (nos. 4, 13, 19, 22, 25). Patient no. 7 was unusual in that he displayed little in the way of psychotic ideation but had great difficulty in relation to his marital and vocational situation. Although there were exceptions, patients were usually uninterested in the reason for their improvement although most of them attributed it to operation and the families were generally enthusiastic about the results. Clinically there was no loss of intellectual ability among these patients and no indication of indolence, lack of initiative, or deterioration of personal habits. This was in marked contrast to some of the lobotomized patients (nos. 5, 11, 20) in whom such signs were apparent to both the examiner and the families, although it must be pointed out that similar behavior had been characteristic of them before operation. There was no consistent change in the sexual life of these patients and many of them reported that dreams had continued after operation (nos. 4, 19, 22, 42, 49) although only 2 of the patients complained that their dreams were disturbing.

Five of the topectomized patients (nos. 6, 8, 13, 40, 42) and 2 of the lobotomized patients (nos. 5, 20) had at least one seizure each during the total follow-up period. Table 57 indicates the distribution of these by dates, each being grand mal in type so far as is known. No Jacksonian, psychomotor, or petit mal attacks were reported but information on this point is inadequate. Patient no. 8 had a second operation (extension of a topectomy) performed in October, 1948 but his seizures continued thereafter. Medication with phenobarbital and/or Dilantin Sodium was used in most of these cases but the material is insufficient to make an appraisal of the value of these drugs since it is not known definitely that the drugs were used as prescribed. In general, the patients were not frightened by their seizures and they did not interfere with the psychiatric improvement of the patients (Levin, Greenblatt, Healey, and Solomon, '49).

Of particular interest in this study was the part which seemed to be played by the social service department of the hospital and by the families of the patients in initiating or maintaining an adjustment outside the hospital. Two of the unoperated patients, (nos. 12, 34) at-

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separate such influences from other factors such as the type of operation performed or the type of illness represented in the patient. The role of individual dynamics and of factors such as maternal overprotection has been completely unexplored but there is enough suggestive evidence in the follow-up studies of these patients to warrant further study of the social environment as it affects recovery. The policy of the hospital in encouraging home visits and aiding the patient in obtaining outside placement appears to have been wise in spite of the fact that some patients were unable to make the adjustment at home, since many patients both operated and unoperated who continued to show obvious psychopathology were able to make a satisfactory life for themselves with the aid of family support.

SUMMARY

1. Individual reports are presented indicating the status of the original Columbia-Greystone patients at the end of 2 years. One patient in the topectomized group died during the second year, after a complete psychiatric relapse and one other patient had to be returned to the hospital. One other topectomy patient and one unoperated patient were able to leave the institution and make a home adjustment during the second year. One lobotomized patient was returned to the hospital during the second year and one unoperated patient also relapsed during this period. Thirteen other patients who were at home at the end of one year continued to maintain their improvement at the end of the second year, including 8 topectomies, 3 unoperated cases, and 2 patients who had lobotomies. Of the 8 topectomies in this group, 6 included Brodmann's areas 9, 10, or 46 as a part of the removal and the remaining 2 were confined to areas 11 and 45.

2. The results of interviews with the psychiatrist and with the social worker are discussed in relation to the postoperative behavior of the patients and the role of the family in influencing improvement.

3. The incidence of seizures is reported.

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